Energy utilization and the role of electricity

Submission to the
Royal Commission on
Electric Power Planning
with respect to the
Public Information Hearings

ENERGY UTILIZATION AND THE ROLE OF ELECTRICITY

Submission of

ONTARIO HYDRO

to the

Royal Commission

On Electric Power Planning

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Public Information Hearings

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TABLE OF CONTENTS

6.1 DISTRIBUTION OF ELECTRICITY

6.1.1 Role of Hydro in the Distribution of Electricity

Ontario Hydro was established in 1906 by the Power Commission Act and it operated under that act until 1973. The enactment of the Power Corporation Act recognized the new organization of Ontario Hydro as a corporation as recommended by Task Force Hydro and implemented by the Ontario Government. The second major piece of legislation affecting the distribution of electrical energy in Ontario is the Public Utilities Act. The generation and distribution of electrical energy in Ontario is achieved through a co-operative partnership between Ontario Hydro, the municipalities and the Government of Ontario.

The prime purpose foreseen for Ontario Hydro was to ensure that Ontario was supplied with electrical energy and that this supply was provided under conditions that would best serve the interest of the total community. This was accomplished by the municipal electric utilities in the urban areas and by Ontario Hydro in the rural area.

Hydro's first contracts with the original 14 municipalities were written in 1908. The terms required the Commission to supply the municipalities with the electricity they needed and to build the transmission lines and transformer stations needed to bring the power from Niagara Falls. The municipalities, for their part, agreed to buy the electricity in specified amounts and to buy from the Commission only. The original contracts with the municipalities provided for the delivery of 25,035 horsepower or approximately 18,675 kilowatts. From this beginning, has grown a system capable of generating and distributing 18,700,000 kW of power to serve 2,653,000 customers in the Province.

Hydro's traditional mandate has been to supply power at cost consistent with high standards of reliability, safety and financial soundness. In fulfilling its mandate, Ontario Hydro encouraged consumption in order to attain significant economies of scale which translated into lower unit costs. A part of this program was the promotion of effective and efficient use of electricity through such means

as improved power factor, load management and high insulation standards, primarily because electricity was still, relative to other fuels, a high cost and premium energy source. This policy was appropriate in the past and served Ontario well.

Although the policies encouraging consumption were appropriate in the past, today they are not. The developing awareness of the limits of our finite resources has focused attention on the need to reduce the growth rate of energy use. Also, the increased cost of providing new capacity, along with the attendant effects on the environment and society, makes it essential to pursue an energy conservation program.

Currently Ontario Hydro's generating capacity is 18,700 MW. Until the 1950's almost all generation was hydraulic. Thermal generation on a major scale was introduced to the system in 1951 and by 1975, 58% of capacity and 47% of energy output was thermal. Nuclear generating capacity is currently 2300 MW, expected to grow to the order of 12,000 MW within 10 years. In addition, the Ontario Hydro grid system is interconnected with neighbouring utilities in Quebec, Manitoba, New York and Michigan for mutual operating benefits.

The grid system of Ontario Hydro is comprised of 500 kV, 230 kV and 115 kV lines which tie the generation facilities to major transformer and switching stations for the transfer of bulk power throughout the Province. Subtransmission lines at 44 kV, 27.6 kV and 13.8 kV take power from these bulk stations and deliver it to municipal utilities, distribution stations in the power district and directly to some large industrial customers. The lines emanating from distribution stations are for local delivery at such voltages as 12 kV, 8 kV and 4 kV for transformation to the utilization voltage provided to households, commercial premises and industry. Some large customers and municipalities take delivery of power at 230 kV and 115 kV,but most take delivery at one of the lower distribution voltages. A number of local distribution systems operate at 27.6 kV and 13.8 kV within their jurisdictions, and a general trend has developed towards supply at these voltages.

For economic reasons,in 1948 a frequency standardization program was undertaken to convert the 25 hz system to 60 hz. Today there are approximately 400 MW of 25 hz generating capacity remaining, mainly in the Niagara Peninsula and northeastern Ontario. Some industrial and mining customers continue to purchase 25 hz power because of mutual economic advantages to them and Hydro.

6.1.2 Distribution to Municipal Electric Utilities

There are 353 cost contract municipal utilities operating in the province ranging in size from the Police Village of Priceville Hydro System, with its 87 customers using 521,500 kilowatt-hours in a year, to Toronto Hydro with approximately 211,000 customers using over 6,550 million kilowatt-hours.

Table 6.1-1 gives some indication of the general size of the municipal utilities in Ontario.

Table 6.1-1

Size of Municipal Utilities in Ontario

Customers	Number of Utilities
less than 1000	197
1000 to 5000	107
5000 to 10,000	15
10,000 to 100,000	30
over 100,000	4

The large and medium size utilities have staff and equipment capable of administering, operating and maintaining the local distribution system. They have a reasonable financial base from which to carry on effective operations. The small utilities have very limited resources, and, in most cases, they rely on Ontario Hydro, other utilities and private contractors to look after such things as meter reading, billing, line maintenance and construction.

Table 6.1-2 further illustrates the range in size of Ontario Municipal Electric Utilities.

Table 6.1-2

Customers, Assets, Expenses and Monthly Peak Loads of Typical Utilities

Utility	No. of Customers	Net Fixed Assets $	Annual Expenses $	Average Monthly Peak Load kW
Priceville	87	15,000	9,000	106
Burlington	26,000	12,500,000	8,500,000	103,000
Toronto	211,376	100,000,000	85,000,000	1,006,000

When a municipal corporation enters into a contract with Ontario Hydro, it entrusts the management of the electric utility to a local commission or council. The conditions for establishment of the utility management are defined in the Public Utilities Act, sections 38 and 40. In the case of a Police Village, the utility undertaking is controlled and managed by the Board of Trustees which has powers and duties the same as a local electric commission. These conditions are set out in the Power Corporation Act, section 67.

The local commission is an agent of the municipality and must keep separate books and accounts for each public utility (e.g., water and electric) it manages for the municipality subject to inspection and audit by the municipal corporation. The authority for borrowing money for the electric utility is vested in local council, but is subject to assent of Ontario Hydro. Such assent is given to the local council, not to the local commission. Remuneration of Commissioners is fixed by council under provisions of the Municipal Act, section 391, subject to approval of Ontario Hydro.

As statutory agent of a municipal corporation which has entered into a cost contract with Ontario Hydro, a local commission has a special relationship to Ontario Hydro. The commission purchases its bulk power requirements at wholesale rates from Ontario Hydro. All retail rates, rents and charges applied

by the local commission for supplying power, or to recover the local costs of providing service, are subject to approval by Ontario Hydro. Capital expenditures, investment of funds, sales, purchases and long term rental of property by the local commission are also subject to approval.

Some local commissions still have hydraulic generating plants in operation and the output of these plants is integrated with power purchased from Ontario Hydro. The output of the municipally-owned plants is shown in Table 6.1-3.

Table 6.1-3

Electric Generation Owned/Operated by Local Commissions

Region	Municipality	1974 Average Generation (kW)
Eastern	Almonte	668
	Bancroft	213
	Campbellford	1,971
	Eganville	263
	Ottawa	7,867
	Renfrew	1,417
Georgian Bay	Bracebridge	1,688
	Orillia	12,977
	Parry Sound	1,052

6.1.3 Distribution to the Power District

Ontario Hydro serves 353 cost contract municipalities and the Power District. The Power District is defined as those customers not served by a local commission. For costing purposes, the Power District is treated as the 354th cost municipality and is made up of the Direct Industrial group of customers and the Rural Retail customers.

6.1.3.1 Direct Industrial Customers

The Direct Industrial customers in the Power District are those having loads in excess of 5000 kW and range upwards in size to 200,000 kW. The average monthly peak load of these Direct Industrial customers in 1975 was 1,924,412 kW. At this time, there are 102 such customers supplied directly by Ontario Hydro. The types of activities, in which these customers are engaged, are summarized in Table 6.1-4.

Table 6.1-4

Summary of Direct Industrial Customers by Type and Load

INDUSTRY	CUSTOMERS	AVERAGE MONTHLY LOAD (kW)
Pulp and Paper	20	*357,642
Cement Making	5	52,488
Steel Making	9	150,780
Abrasives	4	74,536
Petrochemical	12	286,767
Other Manufacturing	12	92,761
Mining	26	539,924
Miscellaneous	14	369,514
	102	1,924,412

* Affected by strikes in 1975, the 1974 figure was 499,454 kW.

An indication of the size, distribution throughout the Province, supply voltage, amounts and classes of power taken, is given in Table 6.1-5.

TABLE 6.1-5

Summary of Direct Industrial Customers by Region, Type of Power Taken and Supply Voltage

Region	Number of Direct Customers	Classes of Power Taken kW			Number of Direct Customers Supplied at			
		Total	Firm	Interruptable	230 kV	115 kV	12-60 kV	Under 12 kV
Northwestern	19	358,737	358,737	-	0	17	2	-
Northeastern	25	619,203	553,566	65,637	2	16	7	-
Niagara	15	296,565	147,796	148,769	-	6	9	
Eastern	23	267,403	185,495	81,908	2	4	15	2
Central	3	64,363	13,015	51,348	1	-	2	-
Georgian Bay	5	22,735	19,875	2,860	1	-	3	1
Western	12	295,406	178,541	116,865	2	4	6	-
TOTAL	102	1,924,412	1,457,025	467,387	8	47	44	3

6.1.3.2 Rural Retail Customers

The rural component of the Power District (Rural Retail System) comprises all of the territory of Ontario except the service areas of all municipal corporations and police villages that have contracted with Ontario Hydro for the supply of power at cost. Power is supplied on a retail basis by Ontario Hydro to a variety of customers in the Rural Retail System and the system is administered by 61 Area Offices throughout the province. The classes of rural retail customers are:

- Seasonal or Intermittent occupancy (cottages)
- Residential (the continuous all-year dwelling)
- General (commercial and industrial customers with loads under 5000 kW)
- Farms

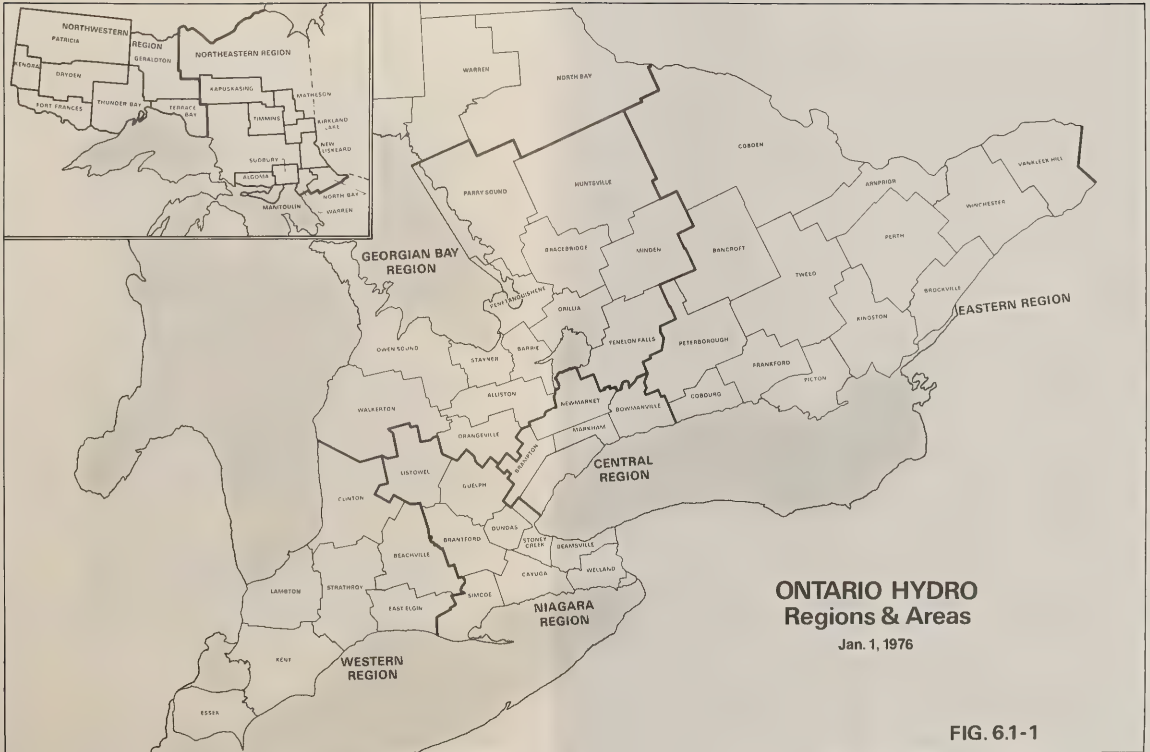
Table 6.1-6 shows the classes of customers by general location in the Province and the miles of local area distribution lines used to supply them.

TABLE 6.1-6

Rural Retail Customers by Region and Class Showing Miles of Lines to Serve Them

Region	Number of Areas	Miles of Line	Number of Customers				
			Total	Seasonal	Residential	Farm	General
Northwestern	5	3,034	25,735	6,543	14,236	1,394	3,562
Northeastern	10	5,761	66,743	11,860	44,888	3,282	6,713
Niagara	9	6,384	92,497	6,583	55,939	22,006	7,969
Eastern	13	14,983	179,951	43,158	92,722	30,593	13,478
Central	4	2,951	76,137	4,493	58,365	6,592	6,687
Georgian Bay	13	12,790	174,672	77,612	62,614	23,069	11,377
Western	7	9,475	103,906	8,469	51,106	35,618	8,713
Local Systems	-	189	27,968	-	24,139	-	3,829
TOTALS	61	55,567	747,609	158,718	404,009	122,554	62,328
% of Total Customers	-	-		21	54	16	9

Figure 6.1-1 shows the location and boundaries of Ontario Hydro's Regions and Areas. The customers in the rural retail system are generally in the more sparsely populated areas of the Province. Line construction in the power district is subject to "density requirements" which stipulate the minimum number of customers required to justify construction.



ONTARIO HYDRO
Regions & Areas
Jan. 1, 1976

FIG. 6.1-1

Line
Number

6.1.3.3 Supply to Remote Communities

The wide variety of conditions encountered in providing service to communities remote from Ontario's bulk power system means that it is difficult to establish a fixed policy for providing this type of service. The line extension policy applicable in the more built-up areas of the Province is not appropriate for remote communities. Lines extended with minimum customer density are not initially self-sustaining even in the more built-up areas, but experience has shown that subsequent customer additions will correct this situation. However, in remote areas, this increase in customers is not anticipated, particularly because these communities are not served by normal transportation methods.

When service to a remote community is considered, a study is undertaken to determine the most economic alternative for providing the supply. At present the choice is between supply from a local diesel generating plant and a line connection to the provinical power system.

Where diesel supply is indicated, all capital requirements, both for the initial installation and for additions to the system, are supplied from sources external to Ontario Hydro. Hydro, in turn, assumes full responsibility for the maintenance, operation and renewal of the plant. Rates for service in diesel supplied communities are many times that in communities with line supply, and are set to recover all costs with the exception of a guaranteed annual subsidy from the Bulk Power System intended to offset any deficit on the diesel systems up to a maximum of $220 per (diesel) residential customer per year.

Where line supply is indicated as being economical, it is accepted that the energy rates shall be the same as apply on the retail (rural) system. The general approach to financing the line supply is that Ontario Hydro prepare estimated operating costs for the facilities necessary and then require sufficient capital from external sources in order to arrive at a break-even position on the operation.

Some examples of the application of the above guidelines are as follows:

Savant Lake

This community was connected to a line supply in 1973 by the construction of a 1000 kVa, 115/25 kV substation and about 50 miles of 25 kV line. The supply was approved at an estimated cost of $611,000 for initial service to a total of 89 customers. This cost was met by a contribution of $106,200 from the Ontario Ministry of the Environment, and total additional contribution of $315,000 from three commercial customers and two government agencies taking power from the new supply. The remaining capital was provided by Ontario Hydro.

Moosonee

Studies undertaken jointly by Ontario Hydro and the Ontario Northland Transportation Commission indicated that connection of existing distribution systems at Moosonee and Moose Factory to the Bulk Power System by the construction of about 90 miles of 115 kV line would be more economic than continuation and expansion of existing diesel systems. The line supply was completed in late 1975, and customers will be supplied at standard Ontario Hydro retail (rural) rates commencing in 1976. All capital costs for establishing this supply, totalling some $5.5 million, have been assumed by the Province, with assistance from the Federal Government pro rata to the share of the total load taken by its agencies at Moose Factory. This full capital assistance was necessary to offset the abnormal costs of maintaining service to this area.

Electrification Of Remote Indian Communities

A program for electrification of remote Indian communities in Northern Ontario is presently underway through the co-operation of the Federal Department of Indian Affairs and Northern Development (DIAND) and Ontario Hydro. For the most part, supply is from diesel plants in the individual communities. DIAND identifies communities to be supplied and provides all funding necessary to establish the supply. The systems are owned and

operated by Ontario Hydro, and service is supplied to individual customers at special rates.

Currently, Ontario Hydro is working with the Ontario Ministry of Energy and DIAND in assessing the feasibility of using supplementary wind generation.

6.1.4 Privately-Owned Industrial-Utility Systems

There are a number of privately-owned industrial-utility systems that have existed for many years as a result of early investment and private development of hydro-electric resources.

6.1.4.1 Gananoque Electric Light and Water Co. Ltd.

Gananoque Electric Light and Water Co. Ltd. serves approximately 2900 customers of which 2500 are in the Town of Gananoque and the remaining 400 in Pittsburg Township. The company has approximately 11 MVA of local generation comprising 5 small hydraulic plants on the Rideau and Gananoque Rivers and 4 thermal units capable of operating on either gas or oil. However, since the hydraulic plants are limited by government regulation of river water levels, there is an increasing reliance on the power supply from Ontario Hydro. For example, in December 1975 Ontario Hydro supplied 5.5 MW, and this is expected to increase to approximately 7.5 MW in 1976 or about 50% of the company's load.

6.1.4.2 Great Lakes Power Corporation

Great Lakes Power Corporation serves the district north from Sault Ste. Marie for about 100 miles and eastward from the Sault for about 20 miles to, but not including, Thessalon. Its hydraulic generating sources are the Michipecotin River (75 MW) and the Montreal River (120 MW) plus an additional 20 MW at the Sault. In addition to these generating sources, the average monthly load to be supplied by Ontario Hydro in 1976 is estimated at 105 MW. This corporation supplies Sault Ste. Marie P.U.C., 18 large industrial customers in the surrounding district and an assortment of residential, seasonal and general class loads between the Sault and Thessalon.

Line Number

6.1.4.3 Canadian Niagara Power

Canadian Niagara Power is a subsidiary of Niagara Mohawk Power Corporation of Syracuse, New York which distributes power in Fort Erie and supplies two industrial customers in Niagara Falls with 25 hz power (Nabisco and Canadian Carborundum).

6.1.4.4 Cornwall Street Railway, Light and Power Company and the St. Lawrence Power Company

The Cornwall Street Railway, Light and Power Co. Ltd. has been owned by Sun Life Assurance Co. since 1902. It supplies approximately 15,000 customers in the eastern two-thirds of the City of Cornwall and the southern parts of Cornwall and Charlottenburg Townships. Its current December peak is in the order of 50 MW. The company buys its wholesale power from the St. Lawrence Power Co. and has a 1-year franchise with the city renewable annually. It supplies two major power customers: Domtar Fine Papers (35 MW) and Canadian Industries Ltd. (25 MW).

The St. Lawrence Power Company is owned by Niagara Mohawk Power Corporation and buys power from the Cedar Rapids Transmission Co. (owned by ALCOA) which in turn buys it from Hydro Quebec (55 MW at 100% load factor running to 1999). This company supplies the westerly 1/3 of the City of Cornwall at the same rates which apply in the remainder of the city.

6.1.4.5 Abitibi Paper Co. Ltd.

The Abitibi Paper Co. Ltd. provides service in the towns of Iroquois Falls and Smooth Rock Falls by means of a 125 kV cable connected to local generation at its mill. In both cases, the distribution voltage is 2.4 kV with Iroquois Falls being supplied from a 2 MVA transformer and Smooth Rock Falls from a 3 MVA transformer.

6.1.4.6 The Ontario-Minnesota Pulp and Paper Co. Ltd.

Under a long term agreement, dating back to 1905, involving the Government of Ontario, the Town of Fort Frances and Ontario-Minnesota Pulp and Paper Co. Ltd., power is supplied to the Town of Fort Frances by the company.

The town's December 1975 peak load was in the order of 16 MW and is growing at the rate of about 6% annually. Since the source of supply to this load is Ontario-Minnosota's Generating Station No. 1 which has a capability of approximately 8 MW, there is a growing dependency on Ontario Hydro to supply the additional power required by the Town.

The town comprises 3000 customers of which 2700 are residential and the balance commercial.

6.1.4.7 The Huronian Co. Ltd. and International Nickel Co. of Canada Ltd. (Inco)

The Huronian Co. Ltd. is a wholly-owned subsidiary of Inco and is engaged in the business of generating and distributing power in the Districts of Sudbury and Algoma. The Huronian Co. has peak generating capacity of 37 MW at 60 hz and 30 MW at 25 hz. The 25 hz power is generated at two hydraulic plants on the Spanish River. Approximately 19 MW of 60 hz power is generated at three hydraulic plants on the Spanish and Vermilion Rivers with the balance of 18 MW generated by two 9 MW back pressure steam turbines utilizing steam from waste heat recovery. The balance of the Company's requirements in the order of 150 MW is purchased from Ontario Hydro.

The Huronian Co. Ltd. supplies power to Inco and distributes power within a 20 mile radius of Sudbury to such communities as Creighton (225 customers) Levack (700 customers) Lively (800 customers) and Copper Cliff (1300 customers).

6.1.5 Regulatory Responsibilities of Ontario Hydro

6.1.5.1 Safety

Every installation of electrical wiring and/or equipment requires inspection and approval by an electrical inspector under the authority of the Electrical Safety Code (Ontario Regulation #168/73). The requirement applies to all new construction, as well as any additions or alterations to existing wiring systems.

The development of the Electrical Safety Code, through a Provincial Code Committee, and the responsibility for ensuring that installations

comply with the Code, are vested in Ontario Hydro through the provisions of The Power Corporation Act, section 94.

To meet the responsibility for electrical safety, Ontario Hydro has established the Electrical Inspection Department having a complement of 205 inspectors who perform the necessary inspections throughout the Province. In addition to the inspection function related to wiring and equipment installations, the department also monitors equipment being offered for sale to the public to ensure that it meets minimum safety standards developed by the Canadian Standards Association subcommittee for the relevant equipment. The Department also investigates fires and accidents involving electrical equipment.

6.1.5.2 <u>Rates and Charges</u>

Ontario Hydro's regulatory responsibility for the approval of rates and charges applied by local commissions is stated in section 96 of The Power Corporation Act. This regulatory role means that Ontario Hydro has the responsibility as well as the authority for approval of the lowest feasible rates, with the related condition that the approved rates should provide reasonable assurance that the local commission's financial viability will be maintained.

The need for a rate adjustment is usually determined initially through consultation between the local commission and Ontario Hydro's Regional Office. Essentially, this process involves a preliminary determination of the local commission's revenue requirements based on its operating expenses and proposed capital expenditures, including the method of financing such expenditures. Each rate adjustment must also reflect the intent of the Federal Government's anti-inflation program and the Ontario commitment to that program.

The Regional Office prepares a rate adjustment proposal in preliminary form and submits it to Head Office for review and comments. This procedure includes an examination of the proposed overall adjustment, its effect on each customer class and the rate levels within each schedule in accordance with established guidelines. Where applicable, Head

Office staff suggests certain modifications to the Regional Office and when concurrence is reached, the Regional Office presents the proposed rates to the local commission for its consideration. At this stage, the proposal is still preliminary in nature. The presentation to the municipal utility indicates that these are the rates Ontario Hydro staff is prepared to recommend for formal approval, but the local commission has the right to make counter proposals. It is essential that important issues be resolved at this stage through consultation between the local commission and Hydro staff. If concurrence does not result from such consultations, the matter is referred to the Corporate Office for consideration and decision. With few exceptions, the issues are usually resolved through the consultative process and the local commission makes formal application for the proposed rate adjustment. This application is forwarded to the Corporate Office for approval on behalf of the Hydro Board of Directors. At the end of each month the Corporate Office approvals are submitted to the Board of Directors for ratification.

6.1.6 Review of Ontario Hydro Wholesale Rates

The Ontario Energy Board Act was amended in 1973 to require that Ontario Hydro's proposed wholesale rates for municipal utilities and for direct industrial customers be submitted to the Minister of Energy not less than eight months before the date of the proposed change. The amendments also permitted reference to the Ontario Energy Board for review of other matters influencing bulk power rates. A rate proposal, once received by the Minister, is referred at the Minister's descretion to the Ontario Energy Board and the Board is required to hold a public hearing with respect to the proposal. The Act stipulates further that the Energy Board shall report on the hearing to the Minister at least four months before the proposed effective date of a rate change.

Starting in 1974 Ontario Hydro's System Expansion Program and Financial Policies and Objectives were, by special reference, reviewed by The Ontario Energy Board prior to its review of the proposed bulk power rates for 1975.

6.2 USE OF ELECTRICITY IN ONTARIO

6.2.1 GENERAL

Ontario Hydro provided 93.4% of the total electric energy within the Province in 1973, the latest year for which complete figures are available. The balance represents net purchases outside Ontario and generation by other utilities and private industry.

The per capita electricity use in Ontario increased from 5,506 kWh in 1958 to 10,616 kWh in 1973, at an average annual growth rate of 4.5% (Table 6.2-1). During the same period, the per capita consumption of all forms of energy grew from 168.6 million BTU's to 254.4 million BTU's at an average rate of 2.8%.

Ontario per capita electricity use is about 7% below that of the rest of Canada. According to the latest United Nations energy statistics, Ontario per capita kWh consumption was 12% higher than the US average, 11% above the corresponding consumption in Sweden, and 112% above the UK average. Norway, which at 16,056 kWh per person in 1972 had the highest per capita electricity use in the world, was 60% above the corresponding Ontario average (1,2,3).

Based on the conversion formula of 1 kWh=3412 BTU, the electricity share of the total energy consumption in Ontario increased from 11.1% in 1958 to 14.2% in 1973. These percentage shares may be misleading because of the high utilization efficiency of electricity at the point of use as compared with other forms of energy.

Table 6.2-1

POPULATION, ELECTRICITY AND ENERGY CONSUMPTION IN ONTARIO, 1958 - 1973

Year	Population	Electricity Consumption	Per Capita Electricity Consumption		Per Capita Energy Consumption	Electricity As Per Cent of Total Energy Consumption
	In 000's	In Billion kWh	In kWh	In Equivalent Million BTU's	In Million BTU's	Per Cent
1958	5,821	32.0	5,506	18.9	168.6	11.1
1959	5,969	35.6	5,966	20.4	180.6	11.3
1960	6,111	37.1	6,080	20.7	178.2	11.6
1961	6,236	38.3	6,138	20.9	180.4	11.6
1962	6,351	40.1	6,320	21.6	184.9	11.7
1963	6,481	42.1	6,492	22.2	194.0	11.4
1964	6,631	45.5	6,867	23.4	200.6	11.7
1965	6,788	49.3	7,259	24.8	211.8	11.7
1966	6,961	53.8	7,732	26.4	215.1	12.3
1967	7,127	56.8	7,975	27.2	219.1	12.4
1968	7,262	61.1	8,420	28.7	226.6	12.7
1969	7,385	64.8	8,769	29.9	226.2	13.2
1970	7,551	69.5	9,203	31.4	240.7	13.0
1971	7,703	73.0	9,471	32.3	238.2	13.6
1972	7,834	79.1	10,096	34.5	249.4	13.8
1973	7,939	84.3	10,616	36.2	254.4	14.2
1958-73 Average Annual Growth	2.1%	6.7%	4.5%		2.8%	

SOURCES: Government of Ontario: Ontario Statistics 1975
Statistics Canada: Detailed Energy Supply and Demand in Canada (57-207,57-505)

A trend in electricity consumption based on estimates of use by market segment within the Ontario Hydro service area is displayed in Table 6.2-2. This basis is different from the traditional method of reporting consumption statistics by rate class. These estimates were prepared to facilitate a more meaningful analysis of electricity use and trends by market segment, and they differ significantly from the rate class statistics used by Statistics Canada and other government agencies.

Table 6.2-2

ESTIMATED PRIMARY* ELECTRICITY USE BY MARKET SEGMENTS

Market Segment	1966 Million MWh	1966 %	1971 Million MWh	1971 %	1974 Million MWh	1974 %	1966-74 Average Annual % Growth
Residential	12.6	28.8	19.3	31.0	23.8	31.4	8.3
Commercial	8.9	20.3	13.9	22.3	20.6	27.2	11.1
Industrial	22.2	50.9	29.0	46.3	31.4	41.4	4.4
TOTAL	43.7	100.0	62.2	100.0	75.8	100.0	7.1

*contracted power, both firm and interruptible

SOURCE: Ontario Hydro: Power Market Analysis Department estimates

It is generally conceded that there is a relationship between economic activity and electricity use. While it is exceedingly difficult to establish precise quantitiative relationships which explain electricity consumption in terms of other variables, Tables 6.2-3 and 6.2-4 illustrate the kind of data that has explanatory potential.

Table 6.2-3

COMPARATIVE STATISTICS IN HOUSEHOLDS, COMMERCIAL AND INDUSTRIAL EMPLOYMENT (in Thousands)

	1966	1969	1971	1974	1966-1974 Average Annual % Growth
Residential Households	1877	2072	2228	2479	3.5
Commercial Employment	1635	1889	2047	2396	4.9
Industrial Employment	1016	1047	1032	1122	1.2

SOURCE: Government of Ontario: Ontario Statistics 1975

Table 6.2-4

NEW CONSTRUCTION IN ONTARIO (in Million Square Feet)

Year	Residential*	Commercial	Industrial	Total
1968	88.0	45.7	19.9	153.6
1969	82.3	57.1	23.2	162.6
1970	81.9	49.7	16.7	148.3
1971	87.3	34.0	11.5	132.8
1972	97.0	51.7	17.6	166.3
1973	111.9	64.7	30.7	207.3
1974	77.4	40.6	28.0	146.0
1975	77.3	32.9	18.9	129.1
Total 1968-75	703.1 (56.4%)	376.4 (30.2%)	166.5 (13.4%)	1246.0 (100.0%)

*New residential construction in terms of dwelling units is shown in Table 6.2-10

SOURCE: Southam Business Publications Limited: Canadata Reports

The breakdown of electricity consumption by its end uses is shown in Table 6.2-5. This type of information is useful in planning for efficient energy utilization.

Table 6.2-5

ESTIMATED PRIMARY ELECTRICITY USE BY SELECTED END USES

	1966		1971		1974		1966-74 Average Annual
	Million MWh	%	Million MWh	%	Million MWh	%	% Growth
Motor Load	21.2	48.5	32.1	51.6	39.4	52.0	8.1
Heating Load	11.8	27.0	15.4	24.8	18.7	24.7	5.9
Lighting Load	8.4	19.2	11.2	18.0	13.1	17.3	5.7
Other Loads	2.3	5.3	3.5	5.6	4.6	6.0	9.1
Total	43.7	100.0	62.2	100.0	75.8	100.0	7.1

Note: Motor load includes all applications where motors are used (for example, it includes oil burners and fan motors on furnaces). Similarly, heating load is limited to all types of resistance, infrared, and induction heating applications, but excludes all motors, even if they represent an integral part of a heating system (consistent with this definition, heating load also includes such resistance heating applications as cooking stoves, water heaters and electric kettles - to name a few).

SOURCE: Ontario Hydro: Power Market Analysis Department estimates

Electricity used by selected applications within each market segment is shown in matrix form in Tables 6.2-6, -7, and -8. It is interesting to note that motor uses constitute a significant proportion of industrial use, while heating applications predominate in residential. In the commercial market segment, motor loads and lighting account for about 90 per cent of the total commercial end use.

Table 6.2-6

ESTIMATED 1974 PRIMARY CONSUMPTION OF ELECTRICITY BY MARKET SEGMENTS AND SELECTED END USES (in Billion kWh)

Market \ End Use	Motors	Heating	Lighting	Other	Total
Residential	5.0	13.2	1.9	3.7	23.8
Commercial	10.5	1.2	8.0	.9	20.6
Industrial	23.9	4.3	3.2	*	31.4
TOTAL	39.4	18.7	13.1	4.6	75.8

*less than .05 billion kWh

SOURCE: Ontario Hydro: Power Market Analysis Department estimates

Table 6.2-7

PER CENT DISTRIBUTION OF 1974 PRIMARY ELECTRICITY CONSUMPTION BY MARKET SEGMENTS

Market \ End Use	Motors	Heating	Lighting	Other	Total
Residential	12.7	70.6	14.5	80.4	31.4
Commercial	26.6	6.4	61.1	19.6	27.2
Industrial	60.7	23.0	24.4	-	41.4
TOTAL	100.0	100.0	100.0	100.0	100.0

Table 6.2-8

PER CENT DISTRIBUTION OF 1974 PRIMARY ELECTRICITY CONSUMPTION BY END USES

Market \ End Use	Motors	Heating	Lighting	Other	Total
Residential	21.0	55.5	8.0	15.5	100.0
Commercial	51.0	5.8	38.8	4.4	100.0
Industrial	76.1	13.7	10.2	-	100.0
TOTAL	52.0	24.7	17.3	6.0	100.0

Line Number

6.2.2 USE OF ELECTRICITY IN RESIDENTIAL MARKET SEGMENT

The residential segment is the most homogeneous, and is, therefore, relatively easy to analyze. Its dynamic and constantly changing nature is depicted in Figure 6.2-1 (4,5,6).

For example, the top curve indicates that in the early forties only about 80% of Ontario residences were electrified and equipped with electric lighting. However, by the mid sixties there were virtually no full time residences without electric service in this Province. Similarly, less than 1/2% of Ontario households today are without an electric refrigerator, while in 1941 only 30% owned them. Electric ranges are in 87% of Ontario homes today as compared with 22% in 1941. Electric water heaters were in only 17% of Ontario residences in 1941 and reached 66% saturation by the mid sixties, but have declined to the 53% level today.

The dynamic change in appliance ownership is perhaps best illustrated by the saturation of washers and television sets. For instance, in 1941 about 52% of Ontario households were equipped with non-automatic wringer-washers; by the mid-fifties their saturation increased to 82%; today less than 25% of Ontario residences use them. On the other hand, automatic washers, which were introduced after World War II, have today reached a saturation of 47%; in other words, since 1972 there were more automatic washers in Ontario homes than wringer washers - in fact there are almost twice as many automatic washers in Ontario homes today than non-automatic ones. The most rapid change, however, has occurred in television ownership. Black and white television sets were introduced in the early fifties; by 1965 they reached their highest saturation, 96%, and have since drastically declined. They are being replaced by colour television sets, which have already reached the 55% saturation level and will probably exceed the saturation of black and white sets by 1977.

FIG. 6.2 - 1

SATURATION OF RESIDENTIAL APPLIANCES ONTARIO

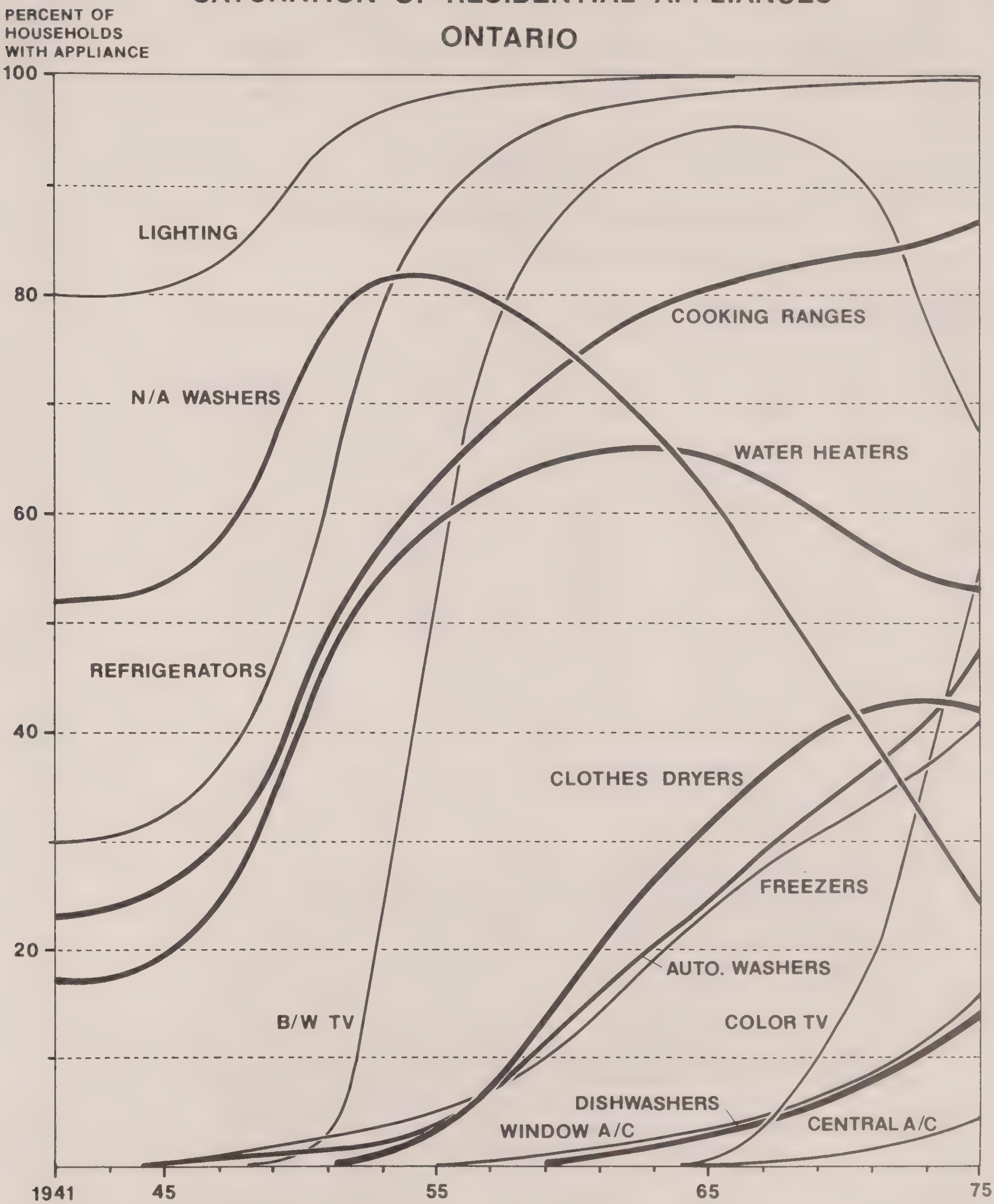


Table 6.2-9 shows the saturation of space heating in Ontario residences since 1960, by type of energy used.

Table 6.2-9

RESIDENTIAL SPACE HEATING SATURATIONS IN ONTARIO, 1960-1975

(Per cent of Households Heated with:)

	Oil	Gas	Electricity	Other
1960	64.9	15.5	0.1	19.5
1962	64.8	21.4	0.3	13.5
1964	62.9	26.6	1.1	9.4
1966	59.1	29.1	2.3	9.5
1968	57.9	32.8	3.1	6.2
1970	55.2	36.4	4.3	3.1
1971	53.9	38.2	5.0	2.9
1972	52.3	39.3	7.1	1.3
1973	51.6	40.1	7.0	1.3
1974	48.6	41.6	8.7	1.1
1975	47.0	42.1	9.9	1.0

SOURCE: Statistics Canada: Household Facilities and Equipment (64-202)

In the last fifteen years, the share of gas heating has increased by 26.6 percentage points to 42.1%, while electric heating has grown from virtually zero saturation to 9.9% of the total heating market in Ontario residences. On the other hand, the oil heating share has decreased from 64.9% in 1960 to 47% in 1975.

The growth of electric space heating in the new housing market in the past sixteen years is clearly depicted in Table 6.2-10. During the past five years, about one out of every four dwelling units built in Ontario was electrically heated.

Table 6.2-10

ELECTRIC SPACE HEATING SHARE IN NEW RESIDENTIAL CONSTRUCTION

(ONTARIO)

Year	New Dwelling Starts	El. Heating Installations in New Dwellings	Percent Share
1959	54,158	380	0.7
1960	42,282	524	1.2
1961	48,144	999	2.1
1962	44,306	2,679	6.0
1963	55,957	4,169	7.5
1964	65,617	8,284	12.6
1965	66,767	9,861	14.8
1966	52,355	11,662	22.3
1967	68,121	11,446	16.8
1968	80,375	10,600	13.2
1969	81,446	13,700	16.8
1970	76,675	13,770	18.0
1971	89,980	21,742	24.2
1972	102,933	25,870	25.1
1973	110,536	27,120	24.5
1974	85,503	20,520	24.0
1975	79,968	20,550	25.7 (Prel.)

SOURCES: Statistics Canada: Housing Starts and Completions (64-002)
Ontario Hydro: Power Market Analysis estimates

Figure 6.2-2 indicates that the use of electricity for space and water heating purposes represents about 50% of the total residential load (4,5,6). In this instance, however, motors for furnace burners and circulating fans are included in the space heating category (see the detailed analysis of 1974 residential electricity use in Table 6.2-11).

FIG. 6.2-2

ONTARIO HYDRO
AVG. RESIDENTIAL CONSUMPTION BY END-USE

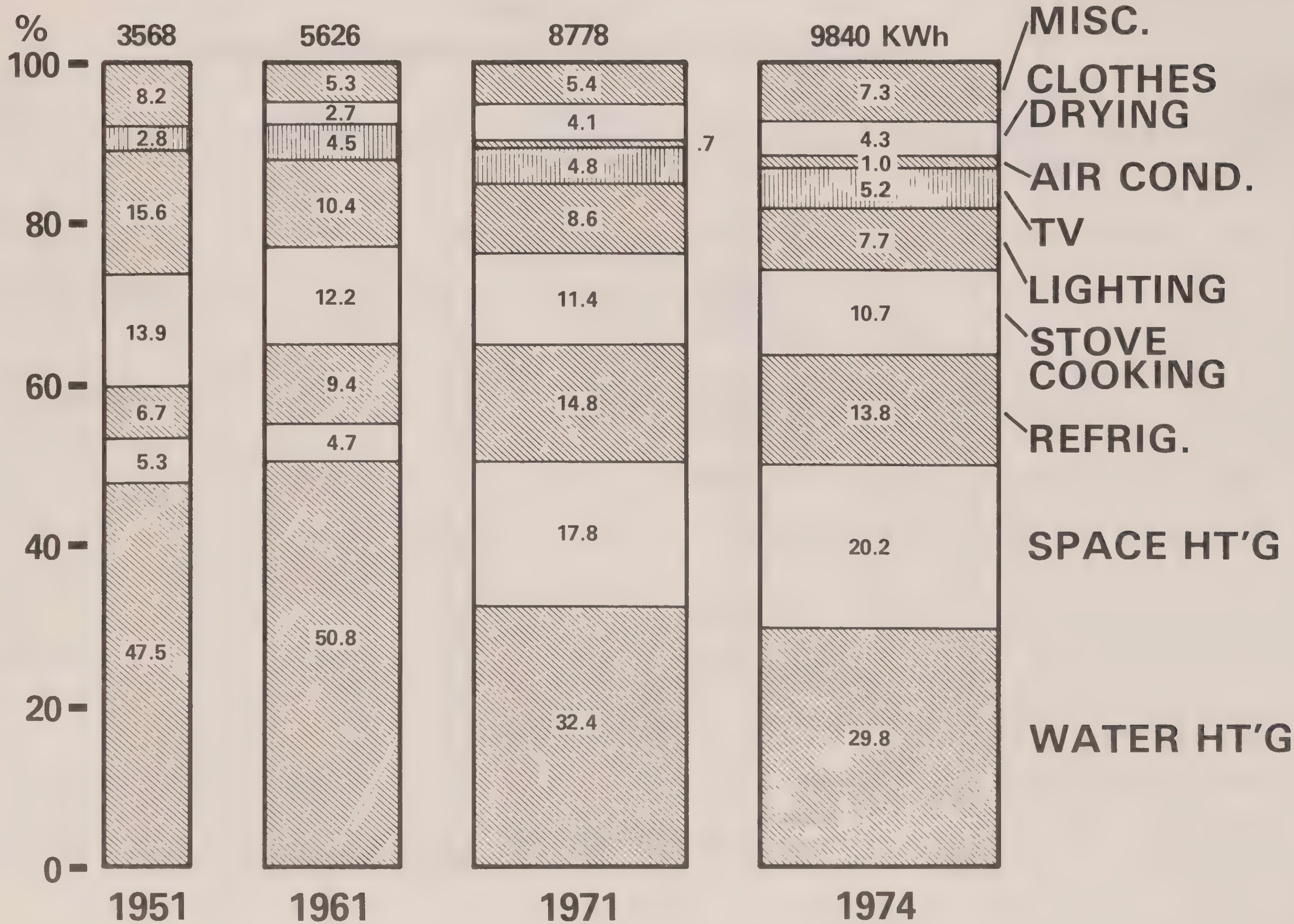


Table 6.2-11

ESTIMATED 1974 ELECTRIC ENERGY CONSUMPTION BY SELECTED RESIDENTIAL CATEGORIES

	Annual kWh per Appl.	Sat'n	Number of Households Using	Total kWh	Total Year-round kWh	Total Seasonal kWh	Total Residential kWh	% Dist'n	Contribution to Average Household Consump'n
	kWh	%	(Thousands)	(Millions)	(Millions)	(Millions)	(Millions)	%	kWh
Water Heating	5,400	53.5	1,313	7,090.2	7,090.2	104.9	7,195.1	29.8	2932
Space Heating - electric (weighted)	16,000	8.6	212	3,392.0					
non-electric (weighted) Oil	750	48.6	1,192	894.0					
Gas	500	41.6	1,020	510.0	4,796.0	84.6	4,880.6	20.2	1988
Refrigeration - Refrigerators (weighted)	1,000	99.4	2,438	2,438.0					
- Freezers	900	38.8	952	856.8	3,294.8	30.4	3,325.2	13.8	1357
Cooking	1,200	86.3	2,116	2,539.2	2,539.2	43.2	2,582.4	10.7	1053
Lighting	750	100.0	2,453	1,839.8	1,839.8	15.3	1,855.1	7.7	758
Television - B/W	350	72.7	1,785	624.8					
- Color	550	46.3	1,137	625.4	1,250.2	4.6	1,254.8	5.2	512
Air-Conditioning (weighted)	600	17.1	419	251.4	251.4	-	251.4	1.0	98
Miscellaneous					2,708.6	85.1	2,793.7	11.6	1142
Total Residential Consumption (of 2,453,000 households)					23,770.2	368.1	24,138.3	100.0	9840

(Average Annual Consumption per household: - 9,840 kWh)

SOURCES: Statistics Canada: Household Facilities and Equipment (64-202), Ontario Hydro: Energy Application Survey 1974
Ontario Hydro: Power Market Analysis Department estimates

6.2.3 USE OF ELECTRICITY IN COMMERCIAL AND INDUSTRIAL MARKET SEGMENTS

Unlike residential, the commercial and industrial market segments are highly heterogeneous in terms of electricity use and therefore are difficult to analyze. (Their aggregate uses are summarized in Tables 6.2-2, -6, -7 and -8.) When expressed on the "per employee" basis, it appears that the average use per industrial employee has recently stabilized at around 28 MWh. The corresponding commercial average use in 1974 was 8.6 MWh and is growing at an average annual rate of about 6% (Table 6.2-12).

Table 6.2-12

TREND IN "PER EMPLOYEE" ELECTRICITY USE IN COMMERCIAL AND INDUSTRIAL MARKET SEGMENTS

	1966 MWh	1969 MWh	1971 MWh	1974 MWh	1966-74 Average Annual % Growth
Commercial	5.4	6.4	6.8	8.6	6.0
Industrial	21.9	24.3	28.1	28.0	3.1

SOURCES: Government of Ontario: Ontario Statistics 1975
Ontario Hydro: Power Market Analysis Department estimates

The distribution of electricity use in the commercial market segment by type of establishment is shown in Table 6.2-13.

Line Number

Table 6.2-13

COMMERCIAL MARKET SEGMENT

ESTIMATED 1972 PERCENTAGE DISTRIBUTION OF ELECTRICITY USE

Retail trade and services	46.3%
Educational establishments	15.4
Office buildings	12.5
Utility services*	10.8
Hotels, motels, etc	7.4
Hospital, nursing homes, etc	4.0
Other	3.6
	100.0

*includes public transportation, water works, sewage treatment and street lighting

SOURCE: Ontario Hydro: Power Market Analysis Department estimates

The use of electricity in the manufacturing sector, which represents over 80% of electricity consumption in the industrial market segment, is analyzed in Tables 6.2-14 and -15.

Line
Number

Table 6.2-14

USE OF ELECTRICITY IN MANUFACTURING 1964-72
BY STANDARD INDUSTRIAL CLASSIFICATION (SIC) IN MILLIONS KWH
(and rank order)

INDUSTRY	1972	1971	1970	1969	1968	1967	1966	1965	1964
Pulp and Paper Mills	4,305 (1)	3,968 (1)	3,959 (1)	4,022 (1)	3,819 (1)	3,693 (1)	3,825 (1)	3,565 (1)	3,497 (1)
Iron & Steel Mills	3,462 (2)	3,252 (3)	3,167 (3)	2,863 (3)	2,853 (3)	2,634 (3)	2,648 (3)	2,463 (3)	2,169 (3)
Mfr Industrial Chemicals	3,220 (3)	3,618 (2)	3,771 (2)	3,547 (2)	3,480 (2)	3,124 (2)	3,031 (2)	2,497 (2)	2,327 (2)
Smelting and Refining	1,416 (4)	1,518 (4)	1,572 (4)	1,034 (4)	1,593 (4)	1,436 (4)	1,266 (4)	1,362 (4)	1,166 (4)
Motor Vehicle Parts	987 (5)	911 (5)	722 (7)	745 (6)	667 (7)	563 (7)	480 (7)	423 (8)	301 (8)
Petroleum Refinery	907 (6)	895 (6)	836 (5)	730 (7)	683 (6)	621 (6)	584 (6)	540 (6)	583 (6)
Abrasives Mfrs	859 (7)	717 (7)	792 (6)	748 (5)	757 (5)	767 (5)	918 (5)	793 (5)	721 (5)
Motor Vehicle Mfrs	700 (8)	671 (8)	598 (8)	645 (8)	585 (8)	494 (8)	474 (8)	445 (7)	370 (7)
Synthetic Textile Mills	516 (9)	438 (9)	433 (9)	302 (10)	406 (9)	367 (9)	334 (10)	267 (10)	246 (10)
Rubber Products	409 (10)	368 (10)	372 (10)	388 (9)	344 (10)	356 (10)	353 (9)	325 (9)	302 (9)
(A) Total of Top 10	16,781	16,356	16,222	15,412	15,024	14,055	13,913	12,680	11,682
(B) All Manufacturers	24,513	23,638	23,084	21,671	21,353	19,941	19,541	17,777	16,307
(A) as % of (B)	68.5	69.2	70.3	71.1	70.4	70.5	71.2	71.3	71.6

NOTE: Figures in brackets represent rank order

SOURCES: Ontario Hydro: Trends in Energy Use Within Ontario Manufacturing Industries (PMA-75-5)
Ontario Hydro: Utilization and Conservation of Electricity in Industry in Ontario (PMA-75-6)

Table 6.2-14 shows that ranking of the ten largest manufacturing groups has remained basically the same since 1964. These ten have consistently consumed about 70% of the total electricity used in manufacturing. The largest user groups are pulp and paper mills, iron and steel mills, and manufacturers of industrial chemicals, which together account for almost one half of the electricity use within the manufacturing industry. Further consumption details are shown in Table 6.2-15.

Table 6.2-15

ESTIMATED 1972 DISTRIBUTION OF ELECTIRICTY USE
WITHIN MANUFACTURING INDUSTRIES

SIC	Industry	Electricity Use x 10^6 kWh Motor	Process	Light	Total
100	FOOD AND BEVERAGE	1020.9 (80)	81.5 (6)	183.0 (14)	1285.4
150	TOBACCO PRODUCTS	17.2 (30)	11.5 (20)	28.7 (50)	57.4
160	RUBBER AND PLASTIC	398.7 (55)	140.4 (19)	185.9 (26)	724.9
170	LEATHER INDUSTRIES	26.8 (44)	10.9 (18)	23.2 (38)	60.9
180	TEXTILES	546.3 (71)	28.6 (4)	190.3 (25)	765.0
230	KNITTING MILLS	30.6 (66)	1.8 (4)	14.1 (30)	46.5
240	CLOTHING INDUSTRY	23.8 (61)	2.7 (7)	12.6 (32)	39.2
250	WOOD INDUSTRY	161.5 (72)	9.3 (5)	33.5 (23)	204.2
260	FURNITURE AND FIXTURE	58.4 (50)	9.4 (8)	49.7 (42)	117.3
270	PULP AND PAPER PRODUCTS	4287.8 (93)	57.5 (1)	251.4 (6)	4597.0

SIC	Industry	Electricity Use x 10^6 kWh Motor	Process	Light	Total
280	PUBLISHING AND PRINTING	86.5 (33)	62.2 (23)	115.4 (44)	263.9
290	PRIMARY METALS	4619.7 (81)	910.5 (16)	142.8 (3)	5673.2
300	METAL FABRICATING	494.4 (59)	162.9 (19)	186.7 (22)	844.0
310	MACHINERY INDUSTRY	330.2 (67)	106.4 (22)	55.2 (11)	491.8
320	TRANSPORTATION EQUIPMENT	1111.7 (59)	540.9 (28)	239.8 (13)	1892.2
330	ELECTRICAL PRODUCTS	288.1 (39)	159.6 (21)	293.4 (40)	741.2
350	NON-METALLIC MINERAL PRODUCTS	885.7 (47)	866.5 (45)	155.8 (8)	1908.1
360	PETROLEUM AND COAL PRODUCTS	730.5 (80)	- -	182.6 (20)	913.1
370	CHEMICALS	3081.1 (85)	346.4 (10)	189.9 (5)	3617.6
390	MISCELLANEOUS MANUFACTURING	91.0 (33)	68.1 (25)	114.2 (42)	273.2
TOTAL	MANUFACTURING	18268.9 (74.6)	3599.0 (14.6)	2648.2 (10.8)	24516.1

SOURCES: Ontario Hydro: Trends in Energy Use Within Ontario Manufacturing Industries (PMA-75-5)
Ontario Hydro: Utilization and Conservation of Electricity in Industry in Ontario (PMA-75-6)

The consumption of electricity in the mining sector accounts for approximately 10% of the total industrial segment. The 1972 distribution of electricity use in the mining industry is summarized in Table 6.2-16

Table 6.2-16

1972 DISTRIBUTION OF ELECTRICITY USE IN MINING SECTOR

	Million kWh	%
Gold Mines	285.5	8.5
Iron Mines	1129.0	33.5
Other Metal Mines*	1618.1	48.0
Quarries and Sand Pits	56.2	1.7
Miscellaneous Mines	280.2	8.3
	3369.0	100.0

*Mostly Nickel Mines

SOURCE: Statistics Canada and Ontario Statistical Centre: Census of Mines

Line Number

SOURCES AND REFERENCES

1. Government of Ontario: Ontario Statistics 1975

2. Statistics Canada: Detailed Energy Supply and Demand in Canada (57-207,57-505)

3. United Nations: World Energy Supplies, 1969-1972

4. Statistics Canada: Census of Canada

5. Statistics Canada: Household Facilities and Equipment (64-202)

6. Ontario Hydro: Energy Application Surveys 1960-1974

RELATED MATERIAL

Advisory Committee on Energy: Energy in Ontario - The Outlook and Policy Implications (1972)

Department of Energy, Mines and Resources: An Energy Policy for Canada (1973)

Fisher, J.C.: Energy Crises in Perspective (1973)

Ford Foundation: A Time to Choose America's Energy Future (1974)

National Energy Board: Energy Supply and Demand in Canada and Export Demand for Canadian Energy, 1966 to 1990 (1969)

Predicasts Inc.: World Energy Supply and Demand (1974)

Science Council of Canada, Report No. 23: Canada's Energy Opportunities (1975)

Line Number

6.3 EFFICIENCY IN ELECTRIC ENERGY UTILIZATION

6.3.1 INTRODUCTION

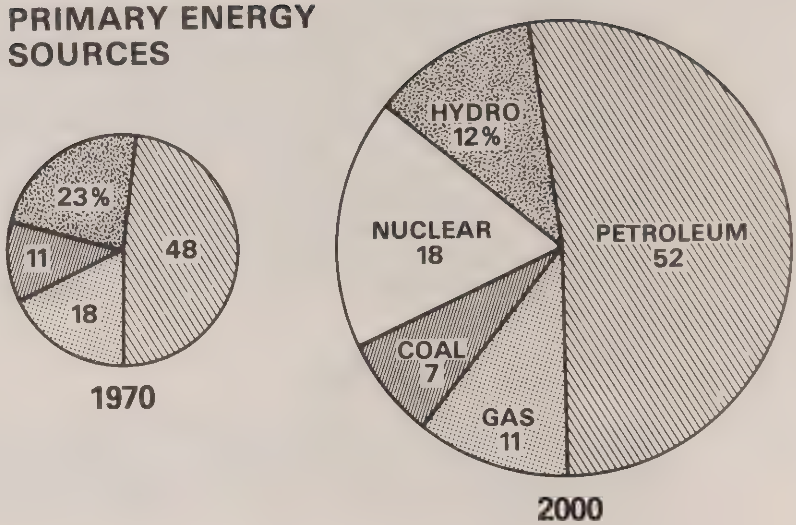
The efficiency of energy utilization is a subject which has been covered in several papers and publications.(1) Much of the material presented here draws on these publications with particular emphasis on the efficiency of electric energy utilization at the point of application and not the efficiency of generation. The material does not consider the conservation aspects of utilization as this will be covered in section 6.4. In addition, a brief review of the national and Ontario energy picture is presented to provide a perspective for the discussion.

6.3.2 PRIMARY ENERGY SOURCES

An understanding of the significance of efficient electric energy utilization in Ontario depends upon a knowledge of the primary energy sources in Canada and Ontario and their use in the generation of electricity.

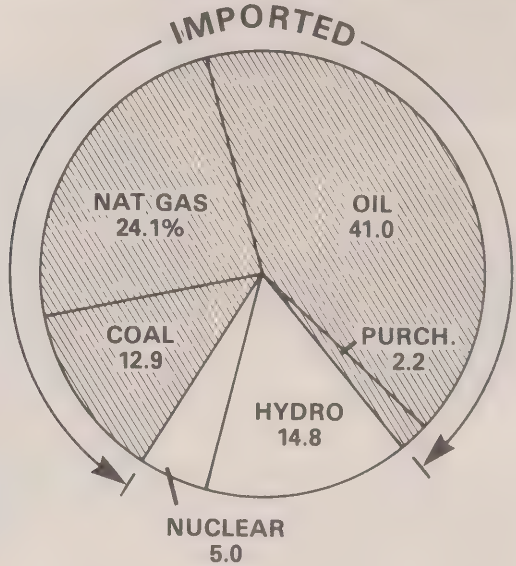
The national primary energy sources in 1970, and projected for 2000, are shown in Figure 6.3-1 which is based on reference (2).

FIG. 6.3-1
CANADIAN PRIMARY ENERGY SOURCES



The significant points to note are the quadrupling of primary energy use, the continuing major dependence on oil and gas, the decreasing importance of hydraulic and the emergence of nuclear fuel as a major source. These conclusions are based on the most recent published data. It is recognized however, that these projections have been overtaken by recent events. More recent projections indicate a growth by a factor of three rather than four. However, the relative shares of the total are not significantly changed.

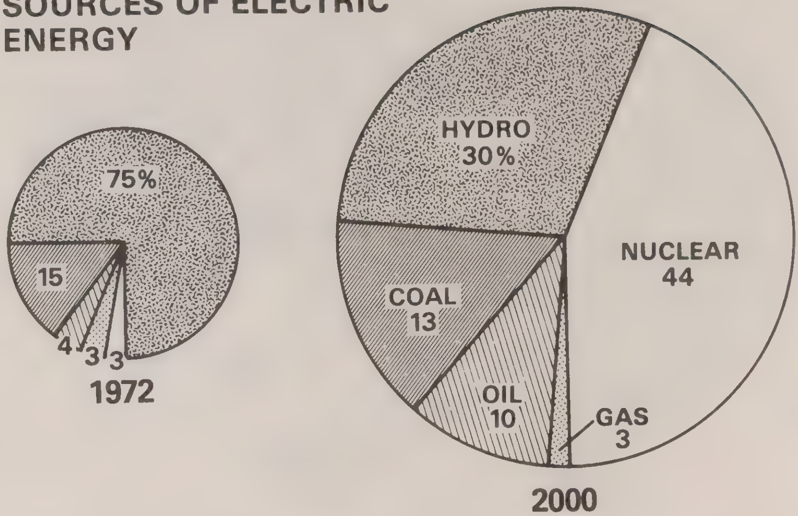
FIG. 6.3-2
1974
ONTARIO PRIMARY ENERGY CONSUMPTION
BY SOURCE AS % OF TOTAL CONSUMPTION



The Ontario primary energy picture, shown in Figure 6.3-2, is very similar to the national picture with the additional factor that only hydraulic and nuclear are indigenous to Ontario. The salient feature to note is that Ontario imports 80% of its primary energy.

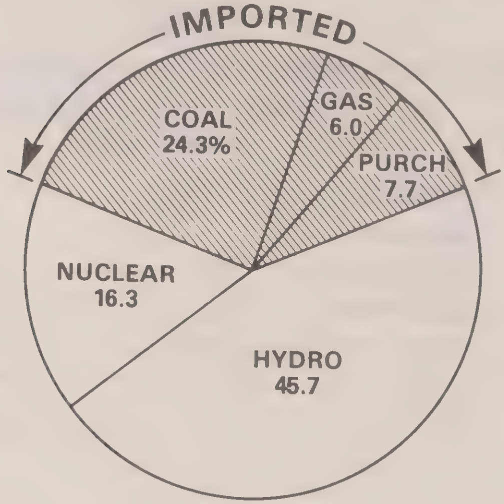
6.3.3 SOURCES OF ELECTRIC ENERGY

FIG. 6.3-3
CANADIAN SOURCES OF ELECTRIC ENERGY



The primary sources of electric energy in Canada in 1972 and 2000 are presented in Figure 6.3-3, also based on reference (2). The principal factors here are the quadrupling of electric energy use, the major decrease in importance of hydraulic from three quarters to one third of the total requirement, and the major share, almost one-half, to be taken by nuclear in the year 2000.

FIG. 6.3-4
1974
ONTARIO ELECTRICITY SUPPLY BY SOURCE



The Ontario situation in 1974, Figure 6.3-4, shows two major differences from the national picture, both indicative of the growing dependence on fossil and nuclear electric generation. Hydraulic provides slightly less than one-half of the primary energy input, compared to three-quarters, and nuclear about one-sixth, compared with about one-fiftieth in the national scene.

The common denominator for both Canada and Ontario is the major dependence of electricity supply on renewable and long-life energy sources. Hydro, coal and nuclear, which are not readily useable in their primary form, provide over 90% of the electric energy.

6.3.4 ELECTRICITY'S SHARE OF ENERGY MARKET BY SEGMENT AT POINT OF APPLICATION

The share of the Ontario energy market which is held by electricity in each market segment at the point of use is shown in Table 6.3-1. Not surprisingly, electricity has essentially no share of the transportation segment, although it represents over 25% of total energy consumption. Electricity's largest share is 22% in the commercial market, primarily because of lighting and space conditioning. In total, electricity provides 15 per cent of the end-use energy market.

TABLE 6.3-1
1975
ELECTRICITY SHARE OF UTILIZATION ENERGY BY MARKET SEGMENT (PERCENT)

TRANSPORTATION	< 1
RESIDENTIAL	19
COMMERCIAL	22
INDUSTRIAL	17.4
ENERGY SUPPLY INDUSTRY	10
TOTAL	15

6.3.5 APPLICATION EFFICIENCY OF ELECTRICITY USE BY END USE

The division of electric energy use by type of application and an estimate of the utilization efficiency of each is shown in the Table 6.3-2. The table indicates that electric energy is used efficiently in motors and heating and that it is the only practical energy source in lighting and communications.

TABLE 6.3-2
1974
ELECTRICITY USE BY APPLICATION

	% TOTAL	EST. EFFICIENCY %
MOTORS	52.0	40—95
HEATING	24.7	80—100
LIGHTING	17.3	5—32*
OTHERS (ELECTRONIC, ETC.)	6.0	*—**

* NO ALTERNATIVE
** EFFICIENCY UNDETERMINED

Electric motors are the most efficient of prime movers and range in size from fractional horsepower to thousands. The tabulated efficiency range of 40-95% takes into account many factors that influence motor efficiency, namely loading and size. Typically, electric motors are loaded below their rated horsepower because a safety factor is included in their selection. The load on the motor is variable: crusher and roller motors idle for long periods. Efficiency is very dependent on size. It is high with large motors which are normally operated with a high load factor and low with small motors which usually operate at low load factors.

Electric space and process heating have traditionally been applied in a careful manner primarily because of high energy cost. Consequently, their efficiency of application is relatively high, 80%.

6.3.6 EFFICIENCY OF ELECTRICITY USE

The efficiency of electricity use in this discussion refers to the efficiency of use at the point of application and does not take into account losses in

the transportation, conversion (generation), and transmission of the primary energy.

The efficiency of electricity use by particular application, rather than the broad classifications discussed above, is shown in Table 6.3-3.

TABLE 6.3-3

EFFICIENCY OF ELECTRIC ENERGY UTILIZATION

SPACE HEATING	
RESIDENTIAL	95–100
COMMERCIAL	95–100+
HEAT PUMPS	150–180
APPLIANCES	
WATER HEATER	90%
RANGE	45
CLOTHES DRYER	40
REFRIGERATOR, AIR CONDITIONER, TV SET, ETC.	UNDETERMINED
LIGHTING	
INCANDESCENT	5
FLUORESCENT	20
HIGH INTENSITY	32

6.3.7 SPACE HEATING

6.3.7.1 Residential

Electric space heating in residential premises is provided by essentially three types: radiant ceiling cable, baseboard heaters and central electric furnaces. The first two types, which represent over 75% of the installations, have an efficiency of 100% at the point of use. The central furnace has an efficiency of about 95%, the losses being primarily from the air distribution system into unheated areas and wall cavities and additional infiltration into the home.

6.3.7.2 Commercial

Where electric heating is used in commercial structures it is usually a baseboard or warm air system having an efficiency of 95%. In large office buildings, internal source heat transfer systems are used which transport the excess heat from the inner core of the building to the perimeter. The thermal efficiency of these systems can be 200-300 per cent or more.

6.3.7.3 Heat Pump

The heat pump extracts heat, usually from the outside air, and delivers it to the space to be heated. In residential and small commercial applications, eg, restaurants and banks, the air source heat pump has an efficiency 150-180 per cent. This means that for every unit of electricity supplied to the heat pump, 1.5 to 1.8 units of heat are delivered to the space. There are very few heat pumps in use at the present time.

6.3.8 APPLIANCES

The utilization efficiency of appliances varies widely, depending on the type of appliance as well as the use made of the appliance. This will be discussed below in more detail for some of the major appliances.

6.3.8.1 Water Heater

The average electric water heater operates at 90% efficiency on an annual basis because of wide-spread acceptance of Hydro initiated and supported insulation and performance standards.

6.3.8.2 Range

The electric range is a relatively inefficient appliance for two major reasons. Firstly, the oven is insulated only sufficiently to keep the stove surface temperatures at a safe level,with oven efficiency not a major concern. Secondly, the heat transfer between the surface elements and the cooking pots is highly dependent on the size, shape and material of the pot and the thermal setting of the element control. Typical electric range

efficiency is 45%. The efficiency of the micro-wave oven is 80%, but its versatility is somewhat restricted.

6.3.8.3 Clothes Dryer

The clothes dryer is about 40 per cent efficient. The major loss in the clothes dryer results from the relatively low drying temperature, limited by heat sensitive fabrics, and the fact that the moist air is normally discharged to the outside.

6.3.8.4 Refrigerator

The efficiency of the refrigerator is a function of two major components: the refrigeration cycle itself and the thermal insulation on the walls of the refrigerator. The coefficient of performance of the refrigeration cycle is determined primarily by considerations of cost and space with minor emphasis placed on thermodynamics. Refrigerator wall thickness is determined primarily by the need to prevent sweating on the exterior surfaces, rather than by any concern for efficiency.

6.3.9 LIGHTING

The utilization efficiency of a light source is referred to as efficacy by the lighting industry and is expressed as the ratio of lighting energy produced to the electric energy required, ie, lumens per watt. Since lumens per watt is not a readily comparable unit for light source efficiency, a simple comparison can be developed by expressing the lumens per watt of a particular light source as a percentage of the lumens per watts of the theoretically most efficient light source. This technique is used here to express lighting "efficiency".

The total electric energy input to interior lighting fixtures is dissipated within the conditioned space and, hence, these efficency values can be misleading. In other words, the lighting load can be useful space heating energy in winter, but is an added cooling load in summer.

The efficiency of the incandescent lamp is 5%, the lowest of common electric light sources. The

efficiency of typical fluorescent lamps is 20%, four times that of incandescent lamps. The efficiency of high intensity discharge lamps is 32%, over 50% better than that of fluorescent lamps.

6.3.10 POTENTIAL IMPROVEMENTS IN UTILIZATION EFFICIENCY

Efficiency improvements are possible in all the various applications noted above, but only improvements in the two largest residential uses of electric energy will be discussed: water and space heating.

6.2.10.1 Water Heating

Although already very efficient, recent studies indicate that higher insulation levels on the water heater would be economically justified over the life of the unit.(3) The largest saving in water heater energy would be accomplished by recovering the useful energy in the waste hot water, particularly from automatic appliances.(4) The economics of this approach are not attractive at present energy prices.

6.3.10.2 Space Heating

Electric space heating is almost exclusively of the resistance type, however the heat pump offers the major potential for increased utilization efficiency. Present day heat pumps have been designed primarily as air-conditioners for use in southern U.S. climates. Recent studies showed that significant improvements in heat pump efficiency could be realized if the equipment design were optimized for heating.(5) Ontario Hydro is presently investigating the technical problems associated with this improvement. Even improvements in heat pump efficiency, of say 20%, would realize significant overall energy savings.

6.3.11 SIGNIFICANCE OF IMPROVEMENTS IN EFFICIENCY

Improvements in the utilization efficiency of various applications of electric energy will not have a major impact on Ontario's total energy use. Traditional end uses of electricity are already efficient and the potential for improvement is small. Since electricity provides 15% of the

Line Number

Ontario energy market, a 20% improvement in utilization efficiency would represent only a three per cent reduction in total energy use. This highlights the importance of increasing the utilization efficiency of oil and gas if major overall energy savings are to be realized.

While some energy savings can result from improvements in end use utilization efficiency, greater savings can be realized by strong energy conservation measures, such as better insulation in buildings, lower thermostat settings and lower use of energy in all electrical applications by changes in life-style.

6.3 REFERENCES

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4. Mastoris, S., Efficiency of Electric Water Heater, Research Division Report 76-138.

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6.4 ONTARIO HYDRO'S ENERGY CONSERVATION/ENERGY MANAGEMENT PROGRAM

6.4.1 INTRODUCTION

The conservation of energy programs currently carried out by Ontario Hydro and outlined in this section are those developed since Hydro first adopted, in May, 1974, a policy to actively promote energy conservation. In recent months the development of serious capital constraints and the resulting reduction in future new generating capacity have necessitated further measures to reduce the electricity growth rate.

To establish an effective future course of action, realistic conservation objectives or targets must be set that will bring existing electrical usage and load growth within the capacity limits imposed by the restrictions on available capital. It is necessary to determine the level of potential reductions, where they can be achieved, how to go about achieving them, what resources to apply, costs, the schedule on both a short- and long-range basis, and how to monitor progress.

An issue of prime importance is the determination of energy (kilowatt-hours) and demand (kilowatts) goals for reduction. This involves detailed analytical work presently underway in assessing potential energy reductions by classes of customers, type of use, system characteristics, and identification of the best opportunities for reduction. The effect of price level and structure on the level of utilization is being analyzed, and the relative importance of kWh and kW reductions is to be assessed in order to determine the direction and nature of the efforts to be taken.

Table 6.4-1 presents a rough estimate, based on 1974 electricity consumption, of the potential energy savings by market segment and end-use largely through change of habit, reduction of waste and, to a lesser degree, application of known technology.

TABLE 6.4-1

1974 ONTARIO HYDRO END USES
MILLION MWh

(SHORT TERM CONSERVATION POTENTIAL)

	MOTORS	HEAT	LIGHT	OTHER	TOTAL
RES.	5.0 (.3)	13.2 (1.3)	1.9 (.2)	3.7 (.4)	23.8 (2.2)
COM.	10.5 (1.1)	1.2 (.1)	8.0 (2.4)	.9 (*)	20.6 (3.6)
IND.	23.9 (.7)	4.3 (.4)	3.2 (*)	* (*)	31.4 (1.1)
TOTAL	39.4 (2.1)	18.7 (1.8)	13.1 (2.6)	4.6 (.4)	75.8 (6.9)

*LESS THAN .05 MILLION MWh

In addition to the conservation potential shown in Table 6.4-1, the following table includes estimates of the potential energy savings which might be achieved if newly added customers also adopt conservation measures:

Table 6.4-2

Potential Energy Savings 1976-1982
(Existing and Newly Added Customers)

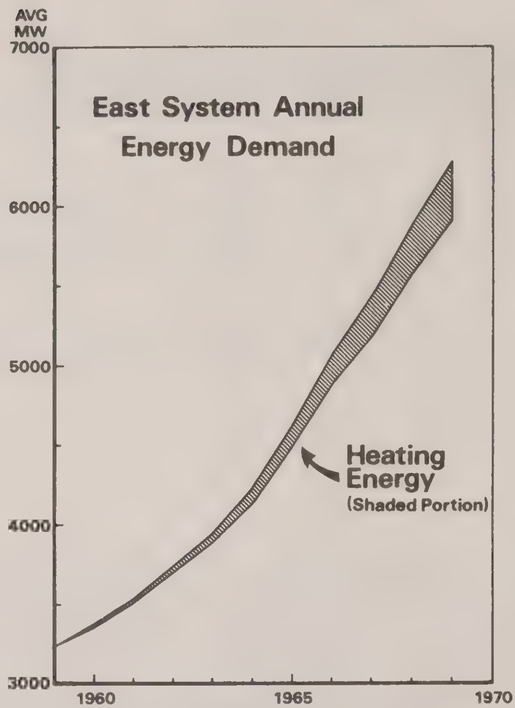
76	77	78	79	80	81	82	
.5	1.3	2.6	5.3	7.0	9.6	12.3	Millions MWh
60	150	300	600	800	1,100	1,400	Average MW
.6	1.3	2.5	4.4	5.6	7.4	8.9	% of System Primary Energy

The data in Tables 6.4-1 and 6.4-2 provide preliminary figures which, at best, are rough estimates of the potential savings achievable through change of habit and the application of known technology. Load management and conservation programs have the potential to bring about a reduction in the order of nine per cent by the end of 1982. The goals for the first three years would be 60, 150, and 300 average megawatts, and these low figures relative to the 1,400 average megawatts projected for 1982 reflect the difficulty in early years of developing and implementing a program of this nature. The 1976 figures also indicate that some conservation opportunites have already been realized through the programs in place during the past two years. Some indication of the "early years" impact of a promotional program is illustrated in Fig. 6.4-1. This shows the estimated effect of electric heating on the system energy demand from the time it was initially promoted in 1960 until 1970 when marketing forces were fully in place, including broad industry support and consumer

acceptance. This promotional program had very little effect in the early years.

Fig. 6.4-1

Estimated Effect Of Electric Heating



6.4.2 WORK WITH GOVERNMENT AGENCIES

The Ontario Government, through the Ministry of Energy, has approached energy management primarily by influencing other ministries, agencies of government and private enterprise to undertake programs on their own.

Ontario Hydro cooperates with various ministries to effect conservation measures. An example is the inclusion in the new Ontario Building Code of improved standards of thermal insulation for all fuels, previously only associated with electric heating. This was accomplished by Hydro staff members and other energy interests working with the Ministry of Consumer and Commercial Relations who are responsible for the Code. As other regulatory

conservation measures are required Ontario Hydro will work with the appropriate ministries and agencies.

Assistance, guidance and training have been provided to the Ministries of Industry and Tourism, Agriculture and Food, Government Services and Education. For example, Ontario Hydro staff provided technical training and material for personnel manning the Ministry of Industry and Tourism's Energy Mobile Support Unit.

6.4.3 ONTARIO HYDRO'S ENERGY MANAGEMENT PROGRAMS

6.4.3.1 Residential Segment

(a) "Conservenergy"
The "Conservenergy" program is an on-going activity to provide material on conservation to Ontario Hydro's area offices and municipal electric utilities to assist them in their efforts to make the public aware of the need to conserve and of the means to accomplish this.

Starting in June of 1974 with the "Wise Use of Energy" booklet, a number of brochures, pamphlets, billing inserts, truck cards, window banners, radio and TV commercials and press releases were produced and distributed. Revised and additional materials have been added to the program during 1975 and 1976.(1) The use of this material by municipal utilities has been increasing as individuals have become more cognizant of the need for energy conservation.

(b) Heat Pump Evaluation and Development

(i) Evaluation
This field activity assesses the effectiveness of design and application techniques of existing residential heat pumps in using energy and determines their reliability from servicing records. Some 300 residential heat pumps installed in the past two years are presently being monitored and are included in the evaluation program to date. Of these, 50

installations have been selected for detailed operational study including energy inputs to compressor, fan and defrost cycle over at least one full heating and cooling season. This study will determine the effects of residential heat pump loads on the electrical distribution system. It will also provide field test data to validate computerized design criteria and energy consumption. The evaluation will provide information to manufacturers and their dealers to enable them to effect product and installation improvements. The instrumentation of the 50 units was completed in March 1976 and a report will be available after the 1976-77 heating season.(2) A similar study has been carried out in the USA, but there is no data on heat pumps for Ontario climatic conditions.(3)

(ii) Development

An Ontario Hydro research program to develop a residential heat pump more suitable for Canadian climatic conditions is being carried out jointly with the Canadian Electrical Association who have contributed to the funding. Present day heat pumps have been designed primarily for cooling in the warmer climate of the southern USA where minimal heating is required. A heat pump for the Canadian climate must give reliable and efficient operation, a long life expectancy, and a seasonal co-efficient of performance (COP) of 2.0-2.5. (Over the heating season, for every kilowatt hour of energy input two to two and one-half kilowatt hours of equivalent heat energy output would be obtained). The best seasonal COP expected from existing heat pumps is 1.5 to 1.8 in Southern Ontario.(4)

(c) Electric Space Conditioning

Ontario Hydro's interest in residential electric space conditioning is to ensure that those customers who install electric heating are provided with accurate design and

application criteria to provide efficient use and satisfactory performance, and is to encourage among the building trades and equipment manufacturers, a uniformity of standards for design, application and performance. To achieve these objectives Ontario Hydro has undertaken the following activities.

(i) Insulation inspection and verification of design calculations carried out on a spot-check basis to encourage proper application of these insulation standards until such time as local building inspectors can assume this function.

(ii) Training sessions presented to local and provincial building officials, as well as other interested parties on proper insulation application techniques.

(iii) Development of a three-part audio-visual program. This consists of a general presentation on how insulation works and its importance; an instructional presentation directed to insulation applicators and related trades; and an instructional presentation directed to municipal, provincial and federal building officials associated with the inspection of buildings. Over 300 presentations have been given to some 8,500 persons at meetings and seminars across the province in the past two years. Fourteen sets of the audio visual presentation have been purchased by a major insulation manufacturer to provide information to insulation applicators across Canada.

(iv) A Technical Training Program on the proper design, application and installation of electric space conditioning systems. This is constantly updated to ensure that construction trades employ the latest techniques in the interests of efficient energy use and customer satisfaction. Contractors, distributors and others have been encouraged to perform heating design calculations in accordance with the

national CSA Standard C273.1 - Residential Electric Heating Standards.(5) Since April 1975 over 750 contractors have attended refresher courses and present indications are that another 500 will participate. Ontario Hydro also provides training material as the basis for part of course curricula for many trades and vocational schools across the province.

(d) Development of Performance Standards

Historically, electrical products have only had to meet mandatory safety criteria as established by the Canadian Standards Association which is the governing body for electrical equipment certification in Canada. On the other hand CSA plumbing and oil furnace equipment standards are both safety and performance oriented and are required by the appropriate authorities having jurisdiction over equipment installation.

To date electrical equipment and installation performance standards have been developed for residential electric heating design and installation, baseboard heating equipment, water heaters, thermostats, and residential ventilating equipment.(6,7,8,9) Ontario Hydro has been instrumental in the development of the above performance standards and is now an active member of the new CSA Standard Steering Committee on the Performance of Electrical Products (SSCPEP). This nation-wide industry, government and consumer committee is endeavouring to develop and implement performance standards for other electrical appliances or devices where significant energy savings may be expected. Some products currently being considered by national Standards Technical Committees are refrigerators, ranges, room and central air conditioners, electric furnaces and heat pumps. It is not practical to develop such equipment performance standards for Ontario only, as manufacturers resist a multiplicity of standards across the country for a market the size of Canada. Ontario Hydro's aim is to actively support and encourage standards for

products where significant increased energy savings are possible.

(e) <u>Displays</u>

Displays depicting the importance of insulation and "the wise use of energy" are used at major trade shows to convey the energy conservation message to industries and trades who are in a position to influence buying decisions.(10)

Although it is not possible to accurately measure the effect of displays on changing attitudes, there has been a marked interest in the insulation display. Displays will be placed in the following major trade shows and conventions in 1976: Canadian Environmental Exposition, Western Ontario Farm, Canada Farm Show, Showcase 1976, and the Canadian Building Congress. In addition 20 displays sponsored by municipal utilities are expected to be presented in 1976.

(f) <u>Communications</u>

Advertising, and services provided to municipal utilities for their own advertising, are designed to develop a conservation attitude in the minds of the general public, as well as specific audiences in industry, commerce and agriculture.(11)

A study carried out in October 1973 to assess the impact of this advertising indicated that 43% of those interviewed recalled that the advertising messages emphasized the conservation of energy. A second study conducted in March 1975 revealed that the percentage of public recognition had increased to 55% indicating that the advertising has been effective to date in bringing to the attention of the public the need to conserve electricity.

In employee publications Hydro has endeavoured to instil employee awareness of the need for energy conservation. Over 30 articles appeared in 1974-75 indicating activities designed to encourage "the wise use of energy".

(g) Technical Consultation Service

This activity consists of providing technical advice and assistance to customers, designers and builders, upon request, with respect to efficient use of energy for residential applications.

Information is also provided to customers through a series of brochures, booklets and pamphlets on energy conservation aspects of various equipment applications.(1)

(h) Joint Energy Industry Conservation Committee

In 1974 Ontario Hydro was instrumental in establishing the Joint Energy Industry Conservation Committee (JEICC), whose task was to persuade the Associate Committee on the National Building Code to incorporate insulation levels in its code.(12) This involved organizing three energy interests (oil, gas, and electric) for the purpose of promoting energy conservation. The JEICC is also working with federal and provincial governments to obtain tax relief and other financial incentives for energy conserving products. The removal of the federal sales tax on insulation products has already been achieved.

(i) Development of New Techniques for Re-Insulation of Existing Housing Stock

Present methods of reinsulating existing homes have shown beneficial effects in energy conservation. A documented example is a 900 square foot Willowdale house converted to electric heating with no change in insulation levels. This house was re-insulated with 6" of mineral wool in the ceiling, walls blown full and 2 inches in the floor which resulted in a reduction in energy consumption from 18,480 to 9,720 Kwhr per year.

There is considerable room for improvement in both insulating products, such as more

thermally efficient insulation materials, and in application methods, such as minimizing of structural air leakage.

Cold air infiltration into many structures can account for up to one-third of the total heating energy required. To determine the tightness or leakage of houses, Ontario Hydro's Research Division has developed a simple procedure using a portable window exhaust fan to indicate the magnitude and location of air leaks.(13) This technique can be used to identify poor residential construction. It has been used to resolve complaints about excessive heating costs and humidity complaints.

Another method of demonstrating heat losses from residential structures is infra-red thermo-vision detection of such losses.(14) This technique may be used to scan large areas of existing housing stock to reveal excessive heat leakage. Because of the difficulty and expense of obtaining and interpreting the data this program has not been used on a broad basis to date. Some benefit may be obtained through demonstration of the excessive heat losses in selected housing developments, and in assessing the results of re-insulation promotional programs.

6.4.3.2 Industrial Segment

(a) Energy Management Seminars

Seminars for senior executives and plant engineers have been designed to create an awareness of the need for improved energy utilization. The end objective is to have the participants take individual action within their own industry recognizing the fact that a multiplicity of industrial processes and energy applications is involved.

The initial series of seminars for industry commenced in 1974, and was jointly sponsored by the Ontario Ministry of Industry and Tourism and Ontario Hydro. They served as the basis for a "two level" management approach commenced by Ontario Hydro in 1975. The intent of this

approach is to first obtain the understanding and active support of senior management to ensure that the technical and staff resources necessary to implement energy management/energy conservation activities are available within the particular industry.

The first level of Energy Management seminars of the current series (for senior plant management) commenced in 1975. To date 28 of these seminars have been held at major centres across the province with total registration of 728 participants.

A second level of the current series of Energy Management seminars (for the production and plant engineering personnel) commenced in late 1975. In these seminars, in-depth presentations are given on the following subjects which were covered only briefly in the 1974 series:

- Lighting (systems, efficiency, maintenance)
- Heat recovery (concepts, equipment, economics)
- Formation of in-plant Energy Management committees(15)

To date five such seminars have been held with attendance of 177 people. A list of all registrants at the seminars is being maintained for follow-up purposes. Material on various related subjects is being mailed to this group at regular intervals. This printed material, in the form of 4-page folders, covers such topics as lighting, heat recovery, poor utilization voltage, power factor and thermal insulation of process equipment. Other topics are being developed. These Energy Management folders also serve as follow-up material for enquiries generated from advertising in various trade publications.(15)

(b) <u>In-Plant Energy Management Committees</u>

This activity is designed to encourage industrial customers to organize their own energy management committees to improve their plant efficiencies.

Prior to Ontario Hydro's entry into this activity a number of large corporations such as General Motors and International Nickel had already set up Energy Management committees. Hydro is endeavouring to motivate more industries to do likewise through seminars, mailings and plant visitations. Examples include the following:

<u>An Automobile Manufacturer</u>

A visit to the plant by Hydro staff at the request of the company readily identified some 30 items of energy waste. For example, lighting fixtures were noted as being dirty. With the improved light output as a result of proper maintenance, it was estimated that more than 200 fixtures could be removed without affecting production. It was also noted that lights were left on for 24 hours a day, seven days a week, although only two shifts were in operation. Recommendations for reducing energy losses from various process tanks, and for the recovery of heat from various exhaust systems were also made.

<u>An Automotive Parts Manufacturer</u>

In this instance a number of recommendations were made with respect to the lighting system. The first consisted solely of changing the method of switching the existing systems, indicating a potential saving of $11,300 per annum, or 2,260,000 kWh. A second recommendation covered a proposed relamping of one area. The indicated expenditure of $26,000, would generate annual savings of $5,400 or approximately a 5-year payback period at current energy prices. The plant power factor was also analyzed and it was noted that a $20,000 investment would yield annual savings in excess of $14,000 for a payback within two years.

(c) The Ontario Energy Flow Chart

A visual presentation using a three dimensional plastic model demonstrates energy inputs and outputs (both useful and wasted) in all sectors from 1965 and projected to 1985. This presentation has been given to over 75 groups of senior management personnel across the province. In addition it is also included as part of the Energy Management seminars referred to previously. This energy flow chart has been an effective tool in focussing attention on necessity for energy conservation. The presentation has been videotaped by a major oil company and a major steel manufacturer for use in their in-house energy management programs across Canada.

6.4.3.3 Agricultural Segment

(a) Industry Contacts

This activity involves maintaining personal contact with farm equipment suppliers to encourage the selection and use of proper equipment for maximum energy efficiency in specific applications, such as ventilation of animal housing. It also involves the provision of related technical assistance to builders and to field representatives of Ministry of Agriculture and Food. The information provides data on the proper sizing of motors and on farm building environmental control equipment (fans and heaters).

(b) Technical Training and Services

Technical training is provided for contractors and builders. Two key elements used as references for such training are "The Farm Handbook" and "Ventilation Guide" both of which are produced by Ontario Hydro. The objective of this activity is to ensure that energy efficient designs are employed. This technical assistance is also provided to individual customers.

Line Number

6.4.3.4 Commercial Segment

(a) Design of New Buildings

The objective of this activity is to encourage the design of "energy efficient" structures through contacts with building designers, their clients and government ministries. They are encouraged to use, where applicable, good thermal design of the structure, solar heat gains, heat reclamation, low energy input efficient lighting systems, thermal storage and sophisticated control systems. Designers are encouraged to employ computer programs to assess the merits of these variables.

(b) Conservation in Existing Buildings

Existing buildings offer the greatest potential for energy conservation. Some major all-electric buildings have been monitored over the past two years. Energy use data was obtained and compared to the original design estimates and in some cases corrective action taken. Two examples are:

A high school in Nepean Township

Studies done by consultants retained by the school board,coupled with similar studies by Hydro,indicated modifications in operating procedures would result in considerable reductions in both energy and demand. Studies following the modifications showed that in 1975 there was a 29.8 per cent reduction in electrical energy consumed and a 23 per cent reduction in demand over 1974. Annual savings, based on current rates, are approximately $26,000.(16)

Trent University - Peterborough

Following discussions between Hydro and plant operating staff the University has reduced the electrical demand by 22 per cent and trimmed annual energy consumption by 1.5 million kWh, in spite of a 40 per cent increase in building space.(16) This

was accomplished by reduced lighting levels, improved peak load control and modified operating procedures.

In order to assess the potential for overall energy conservation in existing buildings, a survey of 131 apartment buildings and office buildings was conducted. The survey obtained data with respect to all forms of energy used in these buildings. No similar data bank of information previously existed and the results will be of value to other groups involved in energy conservation, such as the federal and provincial energy ministries. Where the survey indicated potential for energy conservation, Ontario Hydro will provide the owners of these buildings with assistance in assessing areas for improvement. The results of this survey serve to support the need for mandatory energy budgets for future buildings by building code authorities.

(c) Energy Application Information

Seminars, brochures and pamphlets have proven effective in providing information to specific audiences,such as design engineers and architects and school boards. These methods of communication can also be used for other groups, such as apartment and office building owners. A technically-oriented periodical entitled "Energy Management", is being produced to reach these interest groups on a wide range of topics, such as lighting system efficiency, pipe insulation and peak load control.(16)

Ontario Hydro conducted a preliminary seminar for approximately 400 members of the staff of the London Board of Education in December 1975. A series of similar seminars on energy management of school buildings is now in the development stage in co-operation with the Ontario Ministry of Education. A series of one-day seminars is planned for custodial staff of school buildings across the province with the objective of effecting energy conservation in these structures. These seminars will be jointly prepared and presented by Ontario Hydro, the gas utilities, and a major

manufacturer of space conditioning control equipment.

(d) Computer Programs

Energy analysis computer programs are available to assist designers in the assessment of various alternative building systems and methods of operation insofar as energy aspects of lighting, heating, ventilating and water heating are concerned. Similar computer programs developed by Ontario Hydro and dealing with heat recovery devices, life cycle costing and thermal storage are available to designers to assist in the development of energy efficient systems. However, the use of these in-house programs has decreased in the past year as designers make greater use of more sophisticated commercially available programs.

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5. CSA Standard C273.1 - Residential Electric Heating (final draft).

6. CSA Standard C273.2 - Performance Standard for Residential Electric Heating.

7. CSA Standard C191 - Performance Requirements for Electric Storage-tank Water Heaters.

8. CSA Standard C260.1 Installation Code for Residential Mechanical Exhaust Systems.

9. CSA Standard C260.2 Residential Air Exhaust Equipment (final draft).

10. Photos of Displays.

11. Copies of typical newspaper and magazine advertisements and employee publication articles.

12. Joint Energy Industry Submission to the Associate Committee on the National Building Code - March 29, 1974.

13. Ontario Hydro Research Division Report No. 72-191-K, May 17, 1972 - Results of Field Survey of Air-Tightness of Single Family Houses.

14. Ontario Hydro Research Division Report No. 75-5-42.

15. Energy Management Brochures and Folders.

16. Ontario Hydro Energy Management Numbers 1, 2, 3, 4, and 5.

RELATED MATERIAL

Ontario Hydro Electric Space Conditioning Instructor's Guide

Ontario Hydro - The Farm Handbook

Ontario Hydro - The Ventilation Guide

6.5 POTENTIAL GROWTH IN THE APPLICATIONS OF ELECTRICAL ENERGY

6.5.1 INTRODUCTION

Despite efforts, through conservation, to reduce the growth of electrical energy consumption and demand, there are certain imponderables that could mitigate against the achievement of these goals. Factors that cannot be quantified at the present time are the effects of:

- consumer perception of long term availability of present energy sources.
- relative pricing of available alternate energy sources.
- consumer preferences
- technological advancement
- regulation and legislation

In addition there is the existing capability of the customers' service entrance equipment and distribution systems. This equipment has been installed in customers' premises to provide not only for present needs, but for increased utilization of electricity. Since July 1963, a 100 ampere service has been the minimum residential standard, and in addition, the electrical safety code requires provision for improved distribution panels to safely accommodate heavy duty circuits for dryers, stoves, water heaters, as well as special circuits in the kitchen area for heavy duty portable appliances such as electric kettles, fry pans, toasters, and microwave ovens. Many older homes, constructed prior to 1963, have had upgraded service entrance equipment installed as major appliances were added to the household or as renovations and additions were made to the structure.

The 100 ampere residential service has given the individual householder the capability to take 23 kW on a short-term peak basis, and approximately 18.5 kW on a continuous basis. The appliances within a residence, such as dryers, fry pans, kettles, and toasters, combined with the existence of 100 ampere

services, provide the householder with the means to impose potential high demands on the electrical supply facilities. These high capacity service entrances permit the average customer to increase his demand significantly by adding supplementary electric heating and other high use appliances.

This potential for increased use of electricity combined with the possible shortages or increased prices of alternate fuels have significant implications to the supply system. It would be very easy to plug in a portable heater or let the electric oven provide some of the home heating requirement if fossil fuels were restricted or become more expensive than electrical energy.

In the commercial and industrial field, the potential for increased use is also evident. New commercial and industrial customers, as well as those carrying out expansion or renovation, have tended to provide electrical facilities to meet their ultimate requirements and many, in fact, have excess service entrance capacity available for future use. As expanded production is required, the increased electrical input to existing, or added, process equipment is usually readily obtained by the alteration or addition to the existing in-plant electrical distribution system. The potential for major increases in electrical requirements is probably greater in commercial and industrial fields than the residential area, barring mass conversion to residential electric space heating.

The following material discusses some specific examples, but by no means covers all applications which might result in increased use of electrical energy.

6.5.2 TRANSPORTATION

Electricity plays no significant role in today's transportation scene except for mass transit, such as subways and trolley busses. As petroleum supplies dwindle a larger role is anticipated in two areas; urban travel and railroads.

6.5.2.1 Electric Road Vehicles

World wide interest has been aroused in electric road vehicles in the past five years and many prototype vehicles have been tested. A few of these have seen limited production.

All of these vehicles are severely limited in both speed and range by the low energy density of the lead-acid battery. Typical performance values are a top speed of 35-40 mph and a range of 30-40 miles. The vehicles are clearly limited to urban application. However, if their first costs were competitive with the gasoline sub-compact car, they could readily serve as a second car for shopping and home to work travel in the urban and suburban community. A recent study by Ontario Hydro indicated that the present high first cost deterrent is likely to disappear when gasoline rises above $1 per imperial gallon.(1)

Present vehicles consume about 0.5 kWhr per mile and for 10,000 miles per year the annual energy consumption would be 5,000 kWhr. This is essentially the same as the residential water heater.

The widespread use of the electric road vehicle depends upon the development of a battery with an energy density ten times that of the lead-acid battery. The sodium-sulphur battery meets this requirement and major efforts are being pushed forward in both the U.S. and U.K. to bring this battery to practical reality. This is not expected to occur before 1980.

A comparison of the use of the primary energy source (petroleum) for either existing electric or gasoline vehicles indicates that they would both require the same quantity of primary energy per vehicle mile. With the superior sodium-sulphur battery, and both vehicles optimized to their application, projections of primary energy use indicate that the electric vehicle would require only 50% of that of the gasoline vehicle.

Widespread use of the electric road vehicle of the future would represent a relatively insignificant addition to the electric utility load and could be

confined to the valley-hours. To the individual household it would be roughly equivalent to the electric water heater. At the same time it would represent a lower requirement on the primary energy sources, and for the householder it would eliminate the gasoline bill.

6.5.2.2 Electrified Railroads

Ontario has no main line electric railroads today. Coal, and then diesel, completely displaced the electric railroad, which was one of Ontario Hydro's first major loads.

Canadian railroads are again looking at electrification because of rising fuel costs, a desire to limit their dependence on a single fuel and the need to increase the freight capacity on certain lines. A major study is presently underway by the Canadian Institute of Guided Ground Transport, Queen's University, sponsored by the Railway Advisory Committee of the Railway Association of Canada,to assess the potential and problems of electrification. The major problem is the high capital costs for the overhead power supply and a new signalling system.

The electric train represents a moving load of approximately 20 MW. For the line from Toronto to Montreal the peak load is estimated to be 80 MW, a relatively insignificant demand on the Ontario Hydro System which has an annual peak of 15,000 MW.

A major railroad electrification - a line of 300 to 400 miles - is not expected to occur in Ontario until 1983 or later. The expansion of railroad electrification in Ontario will be slow because of the high capital cost and the lack of high density long haul lines to justify electrification. Ontario Hydro is monitoring activities in this area through the Canadian Electrical Association representative on the Railway Advisory Committee.(2)

Line Number

6.5.3 CONVERSIONS OF FOSSIL FUEL-FIRED INDUSTRIAL PROCESSES TO ELECTRIC HEAT

6.5.3.1 Heat Treating

Heat treating furnaces supply heat to metal parts for long periods of time and at fixed temperature. They are used to slightly change the chemical composition of the metal or the crystalline structure resulting from the forming operations such as rolling, forging, and machining. They are usually fired by gas or oil, because they have been cheaper than electricity, and very often a reducing atmosphere is required which is conveniently supplied by the use of fossil fuels. Existing flame-fired furnaces can be converted to electric heat, but with some difficulty and possible loss of capacity. New furnaces now on the market are better built, use higher levels of insulation, can be equipped with recuperators and can use either gas or electricity. However, the majority of new heat treating furnaces are electric. Electricity can control the temperature more accurately (solid state controls), provide higher temperatures and the energy input can be reduced for idling and material changing.

6.5.3.2 Forging

Forging is a metal forming process which usually requires heating only part of the metal to be forged. The oil-fired slot furnace, customarily used, has a very low efficiency, but is cheaper than electricity both to purchase and to operate for small production runs. At higher production rates the electrical induction furnace becomes practical and economical to use.

Induction furnaces lose very little heat to the surroundings and draw power only when they are heating. While the efficiency of converting the electrical supply frequency to the higher frequencies used in the heating coils is 90%, the overall efficiency is closer to 50% because of the need to water-cool the coils.

Major furnace manufacturers in the U.S. report increased interest in the use of electrically powered equipment with the percentages of gas fired

and electric furnaces being reversed from their historic positions. Large manufacturers, such as Caterpillar Tractor Co. of Illinois, are going heavily into electrically powered furnaces.(3) In Ontario, Eaton Springs Ltd. of Chatham, has installed a large (4200 kW) high frequency induction heating system on the basis of an overall saving of from $2.00 to $3.00 per ton of product processed. Overall application efficiency is approximately 50%. A sister plant in Wallaceburg, using natural gas fired slot furnaces, has a recognized efficiency of less than 5%.

6.5.3.3 Melting

For some years now, foundries, both ferrous and non-ferrous, have been converting their metal melters from coke fired cupola to electric induction furnaces. To some extent this has been associated with a rise in the price of coke, but it has been accelerated because the electric furnace can provide a continuous supply of molten metal at a comparable cost to the batch operated cupola furnace.

The conversion of a foundry to electric melting can commonly increase the demand by 2500 kW or more, depending on casting capability. Foundries having made such a conversion in recent years include:

- General Motors - St. Catharines
- Canron - Toronto
- Brantford Malleable Iron - Brantford
- Western Foundry - Wingham
- Crowe Foundry - Cambridge

6.5.4 IMPACT OF ENVIRONMENTAL REGULATION IN INDUSTRY

The present industrial pollution control regulations will have a great impact on the future consumption of electricity in Ontario. For example, an average of 2000 kWh of energy is used to produce one ton of paper or paper products, and the strict enforcement of the pollution code could increase this amount by as much as 50%. Some industry spokesmen suggest a possible energy-use increase of as much as 100% for "zero discharge" of pollution in the effluent.

To reduce water pollution, Ontario mills are being required to provide waste treatment facilities, such as settling ponds and aerated lagoons. Energy use

in the settling ponds for primary treatment is about 2 kWh/ton of paper, while in aerated ponds the power consumption is about 15 - 130 kWh per ton. Similar conditions exist in other industries where large volumes of liquid effluent are produced. Steel mills have constructed lagoons or ponds for trapping waste materials, such as oil, acid, and dust. The pollution control facility at Stelco's No. 3 blooming and billet mill has a 600 kW load. A similar supply of electricity will be required for Dofasco's recently announced liquid waste control system which will eliminate between 5000 and 8000 gallons of liquid effluent a day from its desulphurization plant.

Ontario steel mills estimate that about ten percent of their electrical power is consumed by the pollution control equipment installed since 1970.

Air pollution resulting from industrial processes can be found in almost every industrial establishment in Ontario. In order to comply with the pollution abatement codes, industries are installing various types of air cleaning systems. All these systems depend on electricity for their operation, primarily for motor load. In and around the steel making furnaces, hot gases are scrubbed and later are passed over precipitators as now required in most localities. Air pollution in the pulp and paper mills resulting from burning of waste by-products can be efficiently controlled with electronic precipitators which use about 1.5 kWh per ton of paper.

6.5.5 HEAT RECOVERY PROCESSES

Proper environmental control in buildings and many industrial processes necessitates the exhaust of large quantities of heated air and smaller quantities of cooled air. In either case, this air contains heat energy that is wasted.

Technology to extract up to 80 per cent of the energy from this exhaust air has been known for the past 50 years. Up until recently it has not been economical to employ this technology extensively. With increasing fuel costs, energy recuperation is now recognized as a viable means of energy conservation.

Applications are numerous and include heat recovery from apartment and office buildings, indoor swimming pools, smelting furnaces and industrial drying. Reclamation technology can be applied to cooling water as well as to exhaust air.

The additional energy required for heat recovery from exhaust air is about 5 per cent of the equivalent energy saved.

Among the devices now available which require varying degrees of electrical energy are:

1. The rotary heat exchanger. This device, driven by a motor of up to one-half horsepower, rotates across the air intake and air exhaust ducts. This is the most popular unit with about 200 now in operation in Ontario. It is the only device that can transfer both sensible and latent heat.

2. The heat pipe. This device also operates to transfer heat energy from the exhaust to intake ducts by transversing both ducts. It is a relatively new development and about 40 units have been installed in Ontario over the past two years. It does not require motive power.

3. The baffle type exchanger. This equipment passes the intake and exhaust air steams through alternate channels. Heat transfer is achieved by conduction. It also does not require motive power.

4. The "run-around-system". This system employs two separate fin-type exchangers, similar to car radiators, connected by piping. This pipe loop circulates the heat transfer medium, usually glycol. It is the least efficient type of heat reclaimer and is used only where intake and exhaust ducts are physically separated. It can also be used where water is the energy source. A circulating pump is always required.

A future heat reclamation device is the High Temperature Heat Pump. This is basically a refrigeration unit to be used where the recuperated temperature has to be increased in order to make it

useful. This equipment is in the developmental stage.

6.5.6 HEAT PUMP APPLICATIONS

6.5.6.1 Residential and Small Commercial

The potential of the heat pump to use the free heat available in outdoor air, water or ground has been exploited in the southern U.S. for over 25 years in residential and small commerical premises. Within the last 10 years they have become more common in the middle and northern states. This growth revealed severe reliability problems, because these early heat pumps were essentially modified air conditioners not designed for heating duty. These problems almost caused the demise of the heat pump in the mid-'50's and again in the early 60's.

Renewed interest in the residential heat pump was evident in Ontario in the early '70's with the introduction of more reliable units. Continued growth is dependent upon relative energy prices, improved heat pump performance, wider availability of competent service, and greater consumer recognition of the pay-back potential from the inherent energy savings.

Air source heat pumps are the most common because of the universal availability of air and the relatively low first cost of this heat pump. Ground source heat pumps are rare because of the high cost of the ground coil and the practical problems of sufficient area and suitable soil conditions in most residential locations. Water source heat pumps are also rare for essentially the same reasons, high well drilling costs and lack of suitable water supply in most locations.

The major shortcoming of the air source heat pump is that its output decreases as the heating load increases. This decreasing capability is compensated for by the use of supplementary heating.

Present day air source heat pumps have an annual coefficient of performance (COP) of 1.5 to 1.8, that is, for every unit of electrical input, 0.5 to 0.8 units of free energy are delivered from the heat source. Recent studies have shown that even with

these relatively low COP's the air source heat pump can be a good investment.(4) It can pay for itself in 10 to 12 years as a heating system and in only 2 to 3 years as a heating and cooling system.

Significant performance improvements are possible in residential air source heat pumps by optimizing their design for the heating function in Canadian climatic conditions. Studies directed toward this objective are presently underway under the auspices of the Canadian Electrical Association in the Research Division of Ontario Hydro. Concurrently, studies of a heating heat pump are being undertaken by Ontario Hydro.

6.5.6.2 Large Commercial Buildings

Many commercial buildings, in particular, office buildings, shopping centers, and large schools, lend themselves to the heat pump concept for space conditioning systems. By their very nature, such buildings consist of large centre core areas which have a year round demand for cooling due to the heat gains from lights, people and machinery. Utilizing heat pump technology, the heat removed from the core area can be used in winter months to offset the perimeter heat losses. In the case of buildings with improved insulation, double glazing and minimal glass area, the structures may be, in effect, "self-heating" during occupied periods down to outdoor temperatures in the range of -7 C to -21 C. This temperature is known as the "balance point".

For new construction, buildings utilizing internal source heat pumps should not add materially to the maximum electrical demand imposed on the system since the refrigeration plant will be of the same magnitude as that of a conventionally air conditioned building. If the building has an excessively high ratio of heat loss to heat gain (i.e. large glass area and low levels of insulation), the "balance point" will be high and some supplementary heat would be required on extremely cold days. This could be in the range of 0 to 3 watts of additional demand per square foot.

The use of internal source heat pumps in such buildings could add approximately 5 kWh per square foot per annum (in the order of 20%) over and above

the electrical energy required by a building with separate cooling (electric) and heating (fossil fuel) plants.

Examples of buildings employing internal source heat pump systems include: Bell Canada Building - Ottawa, Commerce Court - Toronto, Parkside Collegiate - St. Thomas and Hydro Place - Toronto.(5)

The use of the internal source heat pump in renovating existing buildings (i.e. buildings with separate heating and cooling plants) has not been employed to date. If a boiler plant required replacement and fossil fuel prices were to escalate, owners and their consultants might consider such an approach. Existing terminal heating equipment (i.e. radiators, convectors, etc.) in such buildings will probably have been designed to handle 81 C water as opposed to the lower grade heat (about 40 C) available from a heat pump system. Some supplementary heating would be required. This, coupled with poorer thermal qualities of the structure, could result in an increased electrical demand in the order of 5 watts per square foot. A "conversion" of this type could add 8 to 10 kWh per square foot per annum to the electrical requirements.

6.5.6.3 Light Industrial

The heat pump principle also has application as a heat transfer system in industry where excess energy is available from industrial processes, but its temperature level is too low for process application. Development of equipment suitable for delivering energy at temperatures up to 200 C is presently underway in the U.S.

The drying process is another possible application of the heat pump.(6) In this case, the energy input to the heat pump is analogous to a water pump in a fountain. The heat pump removes the energy of vaporization in the discharge from the dryer and delivers it, plus the input energy to the heat pump, to the intake side of the dryer to be used to drive the moisture from the material to be dried. This is a very efficient cycle, thermodynamically, and only the low cost of energy has retarded its development

and acceptance by industry. Ontario Hydro has cooperated with the Forest Products Laboratory in Ottawa in the development of a heat pump for lumber drying. The results are promising but severe installation and servicing problems have to be overcome before it can be widely accepted by the lumber industry.(7)

A study is also underway at Norwich, Ontario to assess the application of the heat pump for crop drying.

6.5.7 THERMAL STORAGE

Thermal storage (coupled with present electrical rate structures) offers certain customers economic advantages. It also enables maximum utilization of the customer's existing electrical plant. At present, these advantages do not necessarily accrue to the power supplier, but, with appropriate adjustments to the rate structure, there is the potential of shaping the system load curve.

6.5.7.1 Domestic Water Heating

Domestic water heating has traditionally been supplied from thermal storage essentially near use temperature (63-71 C).

The technology is now available for high temperature storage systems. Electrically heated high temperature (approximately 120-140 C) hot water storage systems have been employed in a number of recently constructed apartment buildings and hotels. These supply 60 C hot water for the domestic hot water use in the building. The prime advantage to the owner is one of space saving. Such systems can store more energy per gallon than systems which store water at use temperature.

These systems are normally designed to operate in an "off-peak" mode. A common practice is to employ a peak load controller to charge the storage vessel at times of lower electrical demand in other parts of the building system. An alternative method of operation consists of charging the storage vessel for specific blocks of time, e.g., valley hour power concept. This latter approach has been used extensively in the USA, but not in Ontario due

primarily to the absence of valley-hour retail rates.

Owners of existing buildings might convert to electric domestic water heating under certain conditions, such as price and availability of fuels and the need for boiler replacement. High temperature water storage could be used since conventional electric water heaters require more space than fossil fuel systems.

The impact on the electrical system of such a "conversion" cannot be defined too closely since the designer has two variables to work with - storage capacity and electrical input (recovery rate). Probable demand would be in the order of 0.7 to 1.0 kW per suite for a typical apartment building. Annual energy requirement would be in the order of 5,000 to 6,000 kWh per suite. In the case of senior citizens' buildings, both demand and energy values would be about 40% less.

Chemical salts can also be employed as the heat storage medium for domestic water heating. In 1966 Ontario Hydro undertook an extensive laboratory and field evaluation of five high temperature storage water heaters.(8) These units used sodium hydroxide (NaOH) over the temperature range of 120 C to 500 C to store the required energy. The energy was transferred to the domestic water by an intermediate steam heat exchange loop. Although there were several minor technical problems, the field test demonstrated that the concept of high temperature heat storage in NaOH was sound. The principal advantages of the unit were an 80 to 90% reduction in weight, 50% reduction in size and a lower installed cost than for a conventional system. Product development by a manufacturer has not yet reached the production stage.

6.5.7.2 Space Conditioning - Commercial

Energy for space heating (and, in some cases, cooling) can be stored in various media, such as water, steam, masonry, and salts, with water being the most commonly used.

Electric heating systems using hot water, heated during "off-peak" periods and stored in large tanks, are in place in several large schools and a number of industrial applications. As a result of escalating fossil fuel prices and the need for renovation of heating plant, more customers may employ such systems. These systems may supply only a part of the space heating load. Due to the complexity of plant designs and operating characteristics it is virtually impossible to attempt to quantify such potential electrical loads.

The use of thermal storage systems in new commercial buildings is relatively new. Many structures, such as Hydro Place, have an excess of internal heat available from occupants, lights and machinery during occupied hours for much of the winter. This excess heat can be stored for use during unoccupied periods or during extremely cold weather. The thermal storage tanks are also employed to store chilled water during the summer. Normal practice in the past has been to design refrigeration plants (water chillers) to meet peak daytime requirements which can extend over 10-12 hours. With the availability of storage, a lower capacity refrigeration plant operating continuously can provide the cooling requirements 24 hours a day.(5) This concept will reduce the peak electrical demand associated with water chilling by about one third. Energy use, however, will be somewhat greater due to the various pumps associated with this design and losses from storage.

The use of concrete floors as heat sinks has been employed in a number of industrial buildings, such as the Ontario Hydro Central Stores warehouse building. Electric energy is supplied during off-peak periods to an embedded floor heating system. Some new plants could employ this as an economical alternative to conventional heating systems.

6.5.7.3 Space Conditioning - Residential

Residential storage heating has been under review by Ontario Hydro since 1964. Initially the concept was for a storage furnace which would carry the house heating load during a 5-hr daytime period with recharging during the valley hours. Extensive studies were made of the furnace parameters

required. Computer simulations were undertaken to assess the number of furnaces the power system could absorb, the rate incentives that could be justified and the number of furnace sizes required to supply the residential heating market.(9) Studies of the trends in system load curves indicated the need for a furnace with a 16-hour storage capability, that is, suitable for recharging in the valley hours and supplying complete house heating from storage for 16 hours. Furnace costs in 1967 indicated that there would be no market for this equipment.

A recent study of the system load curve, projected to 1990, shows that a furnace with a 16-hour storage capacity would still be required, but the number of furnaces that would fill the valley is relatively small.(10) For example, if all new electrically heated houses used storage furnaces, the valley would be filled in ten years. Any future growth of the storage furnace market would have to be carefully controlled to avoid shifting the peak to night-time.

There have been no extensive studies of small unitary or room type storage heaters to date. Their heat output is difficult to control and they do not meet the heating expectations of most Canadians.

6.5.8 INFRA-RED HEATING

6.5.8.1 Commercial and Industrial

Infra-red radiant heating systems have been employed for many years for localized heating or "people heating" applications in industrial buildings. In a few types of public buildings, such as arenas, grandstands, and churches, infra red has been installed to supply the complete heating requirements.

The relative ease of installation and low first cost make this an attractive alternative to some industries faced with expensive renovations to existing plant or fossil fuel supply problems. This type of heating system can accommodate some degree of peak load control.

Infra-red radiant heating has been applied for outdoor applications, such as loading docks,

stadiums and snow melting. Such applications can result in input densities of from 40 to 100 watts per square foot of area heated. Indoor applications are in the range of 10 to 60 watts per square foot. This type of heating tends to be used intermittently and it is impossible to quantify energy use with any degree of accuracy.

6.5.8.2 Agricultural

(a) Commercial Brooding

Commercial broiler production, turkey brooding and pullet replacement currently account for 44,000,000 kWhrs annually or about 25% of the commercial brooding market.

If the Recommended Code of Safe Practice for the Installation, Operation and Maintenance of Gas and Propane Fired Brooders in Farm Buildings, should become a requirement, many producers would switch to electric infra-red rather than make repairs to existing equipment.(11)

Other factors which could influence this conversion are low equipment and maintenance costs, possible shortages of fossil fuels in rural areas and higher insurance rates for fossil-fired brooders. A brooding temperature of 36 C to 46 C can be maintained at bird level, even if the room temperature is 10 C. This quality of temperature control has significant influence on the energy requirements and operating costs.

If all brooding were done by electric infra-red, 145,000,000 kWhr would be consumed annually and about 102,000 kW of heating load would be added.

(b) Other Uses

There are numerous other current agricultural applications of infra-red radiant heating. Some examples are: lambing sheds, milk parlours, work shops, egg rooms and swine housing. The influence of these on the power system is difficult to quantify.

6.5.9 HEATING OF HIGH DENSITY ROW AND TOWN HOUSING

The possibility of electric heating being installed in existing residential dwellings to replace present oil or gas fired heating systems is most likely to occur in row and town housing units. These types of structures have relatively lower heat loss in total than conventional detached dwelling units because they have only two exposed walls and are predominantly two storey structures. In addition, they already have sufficient electrical service entrance capacity to supply the total heating load.

For example, a 3-bedroom in-line townhouse unit with two exposed walls and approximately 1625 square feet of heated area requires about 12 kW of space heating equipment depending on geographic location in the province. This would add about 20,000 Kwhrs to the annual energy consumption of this unit. The end units of this townhouse row, that is, with 3 exposed walls, would require about 13 kW and add 21,000 Kwhrs to the energy consumption.

On the other hand, a typical 1,000 square foot detached three bedroom bungalow would require about 15.5 kW of space heating equipment depending on location and would add approximately 24,000 Kwhrs to the annual energy consumption of that house.

6.5.10 DISTRICT HEATING

District heating systems have been used extensively in Europe for many years, but have seen limited use in North America. Toronto Hydro operates a district heating system in part of the downtown core. The heating medium, steam, is generated from 2 plants, one a 36 MW electric installation at Terauley Sub-Station, the other a gas fired plant on Pearl Street.

Between 1969 and 1974 a detailed study (The Toronto District Heating Study) was undertaken by the City of Toronto to analyse various aspects of heating in the downtown core.(12) The subject matter included energy conservation, recycling, air pollution, aesthetics and economics. Among many recommendations in the Summary Report was one that called for "Mandatory electric heating, with

district steam optional, where available, for new buildings over 50,000 square feet in the 'Inner Tracts'". Also recommended were incentives to convert existing buildings from individual fossil fuel plant operation to district heating where available and incentives to encourage the use of heat pumps in all new buildings over 50,000 square feet, anywhere within the city.

The report has been approved "in principle" by City Council, but has not been implemented.

6.5.11 SOLAR HEATING

Considerable research and development activity is underway, primarily in the U.S., to increase the utilization of solar energy. The prime purpose is the conservation of non-renewable energy resources and the development of a new technology to provide the energy requirements of society. To determine the probability of success, the systems have been life-costed from the point of view of the customer. The premise has been that the customer would not make any concerted effort to employ such systems without the added incentive of "saving money". Present projections of solar energy system costs indicate that solar energy will not be competitive with other energy sources for residential space and water heating in Ontario before 1990 and even then the saturation will be low and growth is expected to be slow(13).

Despite these projections, Ontario Hydro is interested in solar energy utilization, and the effect it might have on the electric demand and energy use.

The following is a summary of three alternative residential applications of solar energy and their expected effect on residential electric demand and energy consumption.

6.5.11.1 Residential Energy Consumption

Solar energy applications are generally directed toward residential space and water heating. Of the total energy consumption in the average house, space heating represents 70% and water heating 20% so that solar energy could replace 90% of the total

residential energy requirements. This would have a major impact on the electrical energy and demand requirements of the all electric house, but relatively minor impact on these same requirements of the fossil fuel home. For this reason the discussion deals only with the all-electric house.

Solar energy applications impose essentially two types of electric load: motors to drive fans and pumps, and electric resistance heaters to provide back-up heating. The motors are small, 1/3 - 1/2 hp, while the electric heaters could be 10 - 20 kW, depending upon the purpose of the solar system, ie, partial or total solar heating.

6.5.11.2 Solar Energy Systems

Three basic types of solar heating systems are compared for energy consumption and peak demand in a typical all-electric house. These types are:

(a) Solar heating - no storage

This is essentially a solar collector which delivers the collected energy to the house when it is available. All additional energy is supplied from the electric heating system.

(b) Solar Heating - One day Storage

This system has sufficient storage capacity added to the above system to meet the house heating needs for one day from stored solar energy. All additional energy is supplied by the electric heating system.

(c) Solar Heating with Seasonal Storage

This system has sufficient collector area and storage volume to meet the entire heating requirements of the house.

6.5.11.3 Energy and Demand of Solar Heating Systems

(a) Solar Heating - No Storage

On average from October to March the sun shines 3.5 hours per day so that for 20.5 hours a day the house will be heated electrically.

Line Number

Therefore the maximum theoretical contribution of solar energy will be 15 per cent of the total space and water heating energy. This is 15% of the 90% of the total electric requirement which is a 13% reduction in electric energy consumption.

Since this system delivers energy only when the sun is shining, the peak demand of this house will be the same as that without solar heating. Consequently, the load factor will be 13% lower.

(b) Solar Heating - One-day Storage

Adding storage to the solar heating system increases its heating potential significantly. For the Ontario climate such systems would provide from 20 to 50% of the space and water heating energy with 30% being an average value.

Since solar energy provides only 30% of the required energy, the total back-up electric heating system will be required. In addition since the power system peak is becoming increasingly temperature dependent, there is a high probability that the back-up system will operate on the day of system peak. Therefore, although there is a 30% reduction in electric energy, there is essentially no reduction in demand and, consequently, the load factor of such a house would be 30% less.

(c) Solar Heating with Seasonal Storage

The basic design premise of this form of solar heating is that all the space and water heating energy is provided from solar energy. This means that the total solar house, from the point of view of the electric utility, is the same as a fossil heated house with fossil fired water heating.

In addition there would be the minor added load of pump and fan motors for the solar system. These would represent a daily energy consumption of about 4 kWh and a demand of 0.5 kW.

6.5.11.4 Conclusion

In general, solar energy has the potential of significant energy savings (13 - 30%), but with essentially no peak demand reduction. Thus, the customer with partial solar heating will lower the power system load factor and for this reason the growth of solar heating must be carefully monitored so that costs to serve can be properly apportioned.

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6.6 POSSIBILITIES OF FUEL SUBSTITUTION - OUTLOOK

6.6.1 INTRODUCTION

During the twentieth century, there have been dramatic changes in the energy market in Ontario. As the century opened, coal was king and wood was a significant fuel. Hydroelectric power and the internal combustion engine were infant technologies. By the early 1920's electric energy was a dominant source of illumination, and growing in importance for stationary motor power. Electric energy from falling water largely displaced coal fired plants, and the internal combustion engine began to displace the horse.

By 1940, oil was beginning to challenge the predominence of coal as a residential heating fuel. In the early 1950's coal was dealt a further blow by the dieselization of the railways. It gained a new lease on life, however, with the renewal of its use as a fuel for the generation of electric energy as Ontario's hydroelectric potential came to be virtually completely harnessed with the completion of the St. Lawrence project and the redevelopment of the Niagara river in the late 1950's.

At the same time, natural gas came to Ontario, first from the United States, and later from western Canada. This new energy source came very rapidly into widespread use for residential heating where it tended to displace oil and coal for residential space heating, and also in industry. To some extent, natural gas replaced electric energy for residential water heating.

In the 1970's, Canada's conventional oil reserves show signs of maturity and depletion. The principal frontier discoveries have been of natural gas, at high cost. This period has also seen the coming of age of electric energy generated from nuclear power.

Thus the twentieth century has already seen substantial shifts between fuels, but, up to the present, they have not affected the demand for energy in the form of electricity to anything like the degree of their impact upon primary fuels.

In 1973, the worldwide price of all forms of energy quadrupled, and the repercussions of this discontinuity are still being felt. The impact of this fundamental change is still working its way through the system, and will continue to do so for years to come.

One sure effect is to increase uncertainty and to make forecasting an even more hazardous exercise than usual. In particular, electric energy, which has so far been quite aloof from the interfuel fray, may become affected via the price mechanism, via capital availability, and via incomes.

6.6.2 PRICE OUTLOOK

The 12th Annual Review of the Economic Council of Canada published in 1975 contains two energy scenarios. These are for the prices of oil and gas in Canada. They are labelled respectively the moderate price and the high price scenario. In both scenarios the price of oil in Canada is assumed to reach the international price by 1980. The 1975 price of oil in Canada is taken as $8.00 a barrel and the international price at $10.50 a barrel.

Under the moderate price scenario, the international price of oil remains constant to 1980 and increases at 5% per annum thereafter. Under the high price scenario the international price increases at 5% per annum starting in 1974. These prices are in current or nominal dollars, and consequently a constant international nominal price implies that prices are declining in real terms by the amount of inflation. Under the moderate price scenario, a severe balance of payments problem develops after 1977 because of production declines and demand which increases at 4%. In the high price scenario, net imports of oil are reduced substantially because production is higher and consumption grows at only 3%. With respect to gas, the assumption is that prices will be increased to parity with oil by 1980 and will remain at parity.

For the period to 1980, the high price scenario appears to be the more likely, because the prices are expressed in nominal dollars, and these are likely to incorporate the effects of world wide inflation, especially if the predicted recovery in

the economies of the industrialized nations materializes during the years 1976-79. This implies a price increase in real terms of 50% for oil and 85% for gas. The real price increase for electricity is projected at 50%. In the case of electricity, the price increases reflect the higher prices for fossil fuel, higher interest rates which reflect inflationary expectations, and the escalation in the real cost of construction which has taken place in the last few years.

The price of coal imposes a difficult question insofar as prices have increased in the past 3 years in much the same way as oil prices. There is some doubt as to whether this reflects a change in cost or whether it reflects market imperfection due to horizontal integration in the energy supply field. While it is true that the costs of producing coal have increased substantially due to mine safety, environmental regulations and increased labour cost, it remains a matter of some doubt as to whether the cost of producing coal in the long run will be as high as that of oil or gas. The same suspicion arises in the case of uranium.

The price of oil from the Middle East does not reflect the cost of its own production, but so long as the OPEC cartel remains intact, its price will be based on the marginal cost of the best alternative in the rest of the world which is available in substantial quantities. At the present time, this alternative is probably oil from the Athabaska Tar Sands. As the technology develops, the best alternative may possibly shift to synthetic oil manufactured from coal.

Capital constraints in both Canada and the United States are tending to discourage additions of nuclear capacity and, consequently, have the effect, for a given demand level, of increasing the demand by electric utilities for coal and thus exerting upward pressures on its price.

6.6.3 AVAILABILITY OUTLOOK

The prospects are that Canada will become heavily dependent on imported oil after 1977. This oil will necessarily come from the Middle East sources, and

reliability of this supply will be very low, given the political tension in that area. During the 1990's the prospects are that Middle Eastern oil production will reach a maximum, and commence to decline. This will mean: (a) curtailment of consumption and (b) a shift to other sources of energy where substitution is possible. The prospects for massive discoveries of conventional oil in North America on the scale required do not appear to be promising. Consequently, reliance must be placed increasingly upon tar sands or synthetic oil from coal.

The availability of natural gas in the longer run for Canada appears to be quite promising, although the supply situation in the period between now and the mid 1980's may become quite tight. If a shortage develops, it is likely that it will be shared between the domestic and the export markets. It seems probable that the domestic shortfall can be mostly absorbed by prohibiting the use of gas for the generation of electricity. The availability of gas after 1985 is conditional upon adequate prices to cover the cost of recovering it from the Mackenzie Delta, the Beaufort Sea and the Arctic Islands.

The availability of uranium for Canadian requirements will depend to a very great extent upon the export policy which is currently under formulation in Ottawa. Supplies of uranium at reasonable cost are quite limited, but are capable of considerable expansion as the price rises.

Coal reserves are relatively abundant, but their development and use involve quite substantial environmental hazards associated with strip-mining and the problem of sulphur removal. Most of the reserves are located in Western Canada, and, consequently, their development for use in Ontario imposes a very considerable logistic problem.

The production of electric energy results from the combination of primary energy with significant amounts of capital. Both of these are scarce resources. The availability of capital depends upon the ability of the Canadian economy to generate savings and upon the availability of labour and materials. Declining birth rates, which started to

manifest themselves in the early 1960's, will have an impact on labour supply in the mid 1980's and early 1990's, and may dictate a more open immigration policy. The problem of the physical availability of labour is to some extent compounded by a large output of higher education into the Canadian Labour Force as a result of policies adopted in the 1960's. A situation of an overqualified labour force can probably be resolved only by a combination of emigration of surplus educated manpower and immigration of semi-skilled and skilled workers.

The prospects for importing capital from abroad depend upon rates of return in Canadian enterprise being competitive with opportunities elsewhere, and this in turn requires that profitability levels be maintained. It seems likely that the United States will have similar balance of payments problems due to oil imports, and will no longer be a dependable source of capital. The capital demand on the Canadian economy which stems from the energy industries would appear to dictate some shift in investment flows away from other sectors of the economy, such as highways, hospitals, and housing, towards the energy industries.

The energy related investments under consideration are large projects with long lead times which will place considerable demands upon capital, labour, and materials. There may be simultaneous requirements, for example, to build gas and perhaps oil pipe lines from the frontier, to expand the transcontinental rail system to bring coal to Eastern Canada, to develop the Athabaska Tar Sands and to expand the country's electric systems. A bunching of such projects may impose severe strains upon the capacity of the economy.

If domestic savings are to be generated, then growth in real income will need to be maintained. At the same time, the demographic prospects are for an aging population which means that the ratio of employed persons to total population will drop and, consequently, the national production will be achieved by a smaller portion of the population and there will be a relatively larger portion of dependents.

6.6.4 THE OUTLOOK FOR REAL INCOME

The outlook for real income has been lowered by the Economic Council in its 12th Annual Review and lowered quite substantially. The Economic Council has estimated the potential growth rate of the Canadian economy in real terms at 5.5%, and the Council has indicated that the economy was operating at its potential in 1973. In its 12th Annual Review it defines an attainable target with a proper policy mix, which, although in excess of the forecast, falls somewhat short of potential to 1978. It seems likely that demographic factors will operate to reduce the growth rate of potential Real Gross National Expenditure.

Lower real incomes will have a substantial effect on the total demand for energy which is thought to be quite sensitive to income. Consequently, if incomes grow less rapidly, it can be expected that demand for energy will also grow less rapidly.

6.6.5 THE OUTLOOK FOR INTERFUEL SUBSTITUTION

Within the energy sector, however, the response to change in prices and relative prices may alter the energy flows between types of energy quite radically. It has been pointed out above that the flows of oil and gas inputs in the Canadian economy are out of balance with the reserves to support them. These flows presently constitute something in the order of 90% of the non-renewable energy inputs to the economy (Ontario, Canada and the United States), but the reserves to support them constitute only about 20% of the non-renewable energy reserves of oil, gas, coal and uranium.

A measure of the response of demand to price changes is elasticity. However, elasticity is a measure of response only at a point, and is, itself, probably sensitive to the level of price. As prices rise, more and more substitutes come into play, and, consequently, the response of demand to further changes in price tends to be greater. On the other hand, the proportion of total budget spent on energy tends to be quite low (in the order of 6%). This suggests that an increase in price may not significantly affect demand. It has been observed in the past that an increase in the real price of

electricity tends to increase the proportion of the budget spent on electric energy. This suggests that an increase in price is not fully compensated by a fall in consumption. An increase in the price of some other fuel tends to increase the demand for electric energy where substitution can take place. An increase in the price of electricity tends to decrease the demand for electricity. An increase in income tends to increase the demand for electricity because the capital equipment which consume electric energy can be acquired.

With the prospective increases in the prices of the various fuels to 1980, it seems likely that the net effect will not be to decrease the demand for electricity, but rather to increase it slightly. On the other hand, the prospects for incomes to grow less rapidly than they have in the past tends to reduce the growth rate of electric energy. On balance it seems likely that these opposing forces will cancel one another out and, consequently, the demand for electric energy, in the absence of aggressive conservation efforts, may not change very much. However, this demand may incorporate a continuing and perhaps accelerating shift from other forms of energy towards electricity and to primary energy flows away from oil and gas and towards coal and uranium.

On a heating value basis, electricity has always been priced at about three times that of other fuels. This is significant in the case of electricity, because most of the losses involved are incurred before final sale, whereas with other fuels the losses are incurred after the final sale. Thus the price of electricity per <u>useful</u> BTU may not be that different from the price of other fuels. It is important to note that with measurement of energy at the final purchase point, an increased shift to electricity will result in an apparent increase in the total losses involved in energy flows between the point of input and the point of final purchase. However, there may be little or no change in the total loss involved between the point of origin and the point of consumption of useful output in the form of work or heat or light.

Because electricity prices on a heating value basis have always been so much higher than those of

alternative fuels, it has tended to be used more efficiently after final purchase than other fuels. For example, insulation standards in electrically heated homes have always been much higher than standards in other houses. As all energy prices increase in the substantial amounts foreseen, then levels of insulation will increase and greater emphasis on other aspects of utilization efficiency will become more economically attractive. Consequently, the growth in demand for other forms of energy may decline more rapidly than in the case of electric energy.

Electric energy is consumed by durable appliances which involve a capital expenditure by consumers. That is to say, the demand for electric energy is a derived demand. In the short run, a response to increased price must necessarily consist of changes in patterns of use of appliances which are subject to habit. Disinvestment in appliance stock is not likely to be rapid unless a viable market exists for used appliances. Thus the response to price increases may be quite different (and slower) than a response to price decreases. At the same time, the possibility exists for substantial changes in consumption which are of a transient nature until consumers adjust to higher prices (as in the response to an increase in the price of cigarettes, liquor or transit fares).

Because of the appliance ownership problem, the adjustment to higher prices of all forms of energy may take several years to be fully felt.

The time of day impact is also important, but largely unknown.

It is quite possible, and it is the intention of both the governments of Ontario and of Canada to induce changes in consumption habits towards a more frugal use of all forms of energy in order to conserve primary inputs, and in the case of coal to conserve the quality of the environment. It is not possible to predict the degree of success which these efforts will encounter.